Rensselaer Catalog
2003-2004

Undergraduate, Graduate, and Professional Programs
Notice Regarding Changes  All information in this catalog pertains to the 2003-2004 academic year and is correct to the extent that the information was available on the catalog preparation date. However, Rensselaer reserves the right to change the course offerings, tuition, fees, rules governing admission, requirements for graduation and the granting of degrees, and any other regulations affecting its students. Such changes are to take effect whenever the administration deems necessary whether or not there is actual notice to individual students.
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic Calendar</td>
<td>4</td>
</tr>
<tr>
<td>Information Directory</td>
<td>6</td>
</tr>
<tr>
<td>Rensselaer in Brief</td>
<td>7</td>
</tr>
<tr>
<td>Educational Programs and Resources</td>
<td>11</td>
</tr>
<tr>
<td>Research Resources and Centers</td>
<td>21</td>
</tr>
<tr>
<td>Student Life</td>
<td>25</td>
</tr>
<tr>
<td>Admissions</td>
<td>32</td>
</tr>
<tr>
<td>Financial Aid</td>
<td>39</td>
</tr>
<tr>
<td>Tuition and Fees</td>
<td>62</td>
</tr>
<tr>
<td>Academic Information and Regulations</td>
<td>67</td>
</tr>
<tr>
<td>Interdisciplinary Studies Index</td>
<td>97</td>
</tr>
<tr>
<td>School of Architecture</td>
<td>100</td>
</tr>
<tr>
<td>School of Engineering</td>
<td>128</td>
</tr>
<tr>
<td>School of Humanities and Social Sciences</td>
<td>232</td>
</tr>
<tr>
<td>Information Technology</td>
<td>292</td>
</tr>
<tr>
<td>Lally School of Management and Technology</td>
<td>306</td>
</tr>
<tr>
<td>School of Science</td>
<td>322</td>
</tr>
<tr>
<td>Reserve Officer Training Corps</td>
<td>406</td>
</tr>
<tr>
<td>Course Descriptions</td>
<td>412</td>
</tr>
<tr>
<td>Administration</td>
<td>572</td>
</tr>
<tr>
<td>Named Professorships</td>
<td>579</td>
</tr>
<tr>
<td>The Faculty</td>
<td>580</td>
</tr>
<tr>
<td>Index</td>
<td>600</td>
</tr>
</tbody>
</table>
Academic Calendar

Fall Term 2003
August 1
Fall tuition and fees due.
August 18
Residence halls and apartments open for upperclass and new graduate students.
August 22
Dining halls open with breakfast.
August 24
Class of 2007 Convocation.
August 25
Classes begin.
September 1
Labor Day. No classes. Staff holiday.
September 8
Last day for graduate and undergraduate students to add courses or change sections without appeal or to put courses on Audit.
September 19
Last day to file degree applications with Registrar’s Office for December 31, 2003 graduation.
October 10
Midterm break begins after last class.
October 13
No classes.
October 14
Classes resume. Follow Monday class schedule.
October 21
Last day for undergraduates to drop a course and last day for graduate students to drop courses without appeal.
October 27-31
Consultation Week. Advisement for spring registration. Students should consult their faculty advisers.
October 26
Honors Convocation.
October 24-26
Family Weekend.
October 25
Rensselaer Legacy Reception.
November 3-17
Registration for all currently enrolled students for the spring semester.
November 21
Last day for undergraduates to add or remove Pass/No Credit designation.
November 25
Master’s theses and engineering projects due to advisers. Doctoral theses due to thesis professors. Thanksgiving recess begins after last class. Dining halls close after dinner.
November 26-28
No classes.
November 27-28
Staff holidays.

November 30
Dining halls open with dinner.
December 1
Classes resume.
December 5
Master’s theses and engineering project records of completion due in Office of Graduate Education. Last day for final examinations for doctoral theses. Classes end after last evening class.
December 8-9
No classes. Study-Review Days.
December 10-12 and 15-16
Final examinations.
December 12
Doctoral theses due in Office of Graduate Education.
December 15
December 16
Dining halls close after dinner.
December 17
Winter recess begins. All students, whether or not returning for spring term, must vacate residence halls by noon.
December 25
Staff holiday.

Spring Term 2004
January 7
Residence halls and apartments open for spring term.
January 11
Dining halls open with dinner.
January 12
Classes begin.
January 19
Martin Luther King Jr. Day. No classes. Staff holiday.
January 23
Last day to file degree applications with Registrar’s Office for May 2004 graduation.
January 26
Last day for graduate and undergraduate students to add courses or change sections without appeal or to put courses on Audit.
February 16
No classes. Staff holiday.
February 17
Classes resume. Follow Monday class schedule.
March 5
Last day for undergraduates to drop a course. Last day for
graduate students to drop courses without appeal.
Spring recess begins after last class. Contract dining halls
close after dinner.

March 8-14
Spring Break.

March 15
Classes resume. Contract dining halls open with break-
fast.

March 15-19
Consultation Week. Advisement for summer and fall reg-
istration. Students should consult their faculty advisers.

March 22-April 5
Registration for all currently enrolled students for sum-
mer and fall semesters.

March 26-April 2
Grand Marshal Week (Student Government elections).

March 31
No classes.

April 16
Last day for undergraduates to add or remove Pass/No
Credit designation.
Master’s theses and engineering projects due to advisers.
Doctoral theses due to thesis professors.

April 23
Master’s theses and engineering project records of com-
pletion due in Office of Graduate Education.
Last day for final examinations for doctoral theses.

April 28
Classes end after last evening class.

April 28-29
Graduation status check and post-graduation career plans
due.

April 29-30
No classes. Study-Review Day.

May 3
Add/Drop reopens for fall 2003.

May 3-7
Final examinations.

May 7
All contract dining halls close after dinner. Deadline for
completion of “NE” grade requirements for fall 2004
courses.

May 8
Residence halls and apartments close for all students not
participating in Commencement.

May 14
ROTC Commissioning Ceremony.

May 15
Commencement.

May 16
All residence halls close by 11:00 am.

Summer Session 2004

March 22-April 5
Currently enrolled Rensselaer students register for sum-
mer session.

May 16
Residence halls and apartments open for summer.

July 9
Master’s theses and engineering projects due to advisers.

July 16
Doctoral theses due to thesis professors.

July 23
Master’s theses and engineering project records of com-
pletion due in Office of Graduate Education.
Last day for final examinations for doctoral theses.

July 30
Doctoral theses due in Office of Graduate Education.

August 6
Final exams must be complete.

August 31
Official date of August graduation; diplomas mailed to
students after final clearance is completed in late
September. Degree recipients may take part in the May
2005 Commencement ceremony.

Fall Term 2004

August 2
Fall tuition and fees due.
Information Directory

Admissions (Undergraduate/Graduate)
Rensselaer Admissions
(518) 276-6216
admissions@rpi.edu

Alumni Relations
Office of Alumni Relations
(518) 276-6205
alumni@rpi.edu
www.alumni.rpi.edu

Dining
Rensselaer Dining Services
(518) 276-6277
fuscoj2@rpi.edu

Disabled/Learning Disabled Information
Disabled Student Services
(518) 276-2746
dss@rpi.edu

Education for Working Professionals
Hartford Programs
(800) 433-4723
info@rh.edu

Troy Programs
(518) 276-4795
rsup@rpi.edu

General Student Advising
Dean of Students Office
(518) 276-6266
vienj@rpi.edu

Graduate Education
Office of Graduate Education
(518) 276-6488
gradschool@rpi.edu

Housing
Office of Residence Life
(518) 276-6284
Res_life@rpi.edu

International Student Information
International Services for Students and Scholars
(518) 276-6561
havisj@rpi.edu

Minority Student Information
Office of Minority Student Affairs
(518) 276-6272
smithm@rpi.edu

Placement
Career Development Center
(518) 276-6234
tarant@rpi.edu

Rensselaer Union
(518) 276-6505

Transcripts
Office of Student Records and Financial Services
(518) 276-6610
bursar@rpi.edu

Undergraduate Academic Advising
Advising and Learning Assistance Center
(518) 276-6269
steig2@rpi.edu

Undergraduate Financial Aid
and Graduate Loans
Student Records and Financial Services
(518) 276-6813
financial_aid@rpi.edu

Undergraduate Transfer, Part-Time,
and Non-Matriculated Admissions
Transfer Admissions/Special Programs
(518) 276-6216
admissions@rpi.edu

Mailing Address
Rensselaer Polytechnic Institute
110 8th Street
Troy, NY 12180-3590

Telephone
(518) 276-6000

World Wide Web
http://www.rpi.edu
Rensselaer in Brief

Overview
Rensselaer Polytechnic Institute is the nation’s oldest technological research university. A nonsectarian, coeducational institution, the university offers degrees from five schools: Engineering, Science, Architecture, Humanities and Social Sciences, and the Lally School of Management and Technology, as well as interdisciplinary degrees in information technology. The Institute’s long-standing reputation for research and educational distinction draws students from every state and more than 70 foreign countries.

More than 140 degree programs in nearly 60 fields lead to bachelor’s, master’s, and doctoral degrees. Students are encouraged to work in inter- and cross-disciplinary programs that allow them to combine scholarly work from several departments or schools.

The university provides rigorous, engaging, interactive learning environments and campuswide opportunities for leadership, communication, and creativity.

Over nearly two centuries, Rensselaer has maintained its reputation for providing an undergraduate education of undisputed intellectual rigor based on exceptional pedagogical innovation in the laboratory and classroom.

As a research university, Rensselaer has built an outstanding faculty whose research programs include such areas as biotechnology, nanotechnology, advanced materials, microelectronics, information technology, computational modeling and simulation, and electronic arts.

The Institute is especially well-known for its success in the transfer of technology from the laboratory to the marketplace so that new discoveries and inventions benefit human life, protect the environment, and strengthen economic development.

Students
Rensselaer enrolls 5,139 full-time undergraduates and 1,739 full-time graduate students in residence on the Troy, N.Y., campus, as well as approximately 2300 in Hartford, Conn., and in distance learning opportunities around the world.

Self-identified underrepresented minorities account for 9 percent of the undergraduate student body. More than 25 percent are women. It is an exceptionally bright and ambitious group: 65 percent of the members of the class of 2006 were in the top 10 percent of their high school classes.

Students operate the Rensselaer Union and control its $8.5 million annual budget. They belong to 23 NCAA intercollegiate teams, scores of intramural teams, and more than 130 clubs. About 30 percent of men are members of fraternities and 20 percent of women belong to sororities. Students publish a weekly newspaper and operate a 10,000-watt radio station.

Approximately 27 percent of Rensselaer graduates go on to graduate school. The average starting salary for Rensselaer bachelor’s recipients in 2002 was $51,735 and $70,854 for master’s degree recipients, higher than the national averages.

Rensselaer ranks annually among the top 50 national universities in U.S. News & World Report, and its graduate engineering program ranks among the top schools in the United States. SUCCESS Magazine ranked the Lally School sixth best in the country for entrepreneurship.
Faculty and Educational Innovations
Rensselaer’s more than 530 faculty members from both the Troy and Hartford campuses, include a Nobel laureate, National Science Foundation Faculty Early Career Development Award winners, members of the National Academy of Sciences and the National Academy of Engineering, and other eminent professionals.

Rensselaer faculty take pride in their dedication to teaching. In coordination with the Anderson Center for Innovation in Undergraduate Education, Rensselaer’s faculty devote much thought and time to designing more dynamic teaching methods, redesigning curricula, and transforming classrooms into interactive learning environments where students learn by doing.

Rensselaer is the recipient of the “triple crown” of higher education awards—the Hesburgh, Boeing, and Pew Charitable Trust awards for innovations in undergraduate education. Rensselaer is the only technological university to win all of these prestigious honors.

The Carnegie Foundation for the Advancement of Teaching report, Reinventing Undergraduate Education, has cited Rensselaer’s studio classes in “Ten Ways to Change Undergraduate Education.”

Rensselaer’s leadership in the area of interactive learning was recognized when the Institute received an $8.8 million grant from The Pew Charitable Trusts. This grant is aimed at helping the nation’s colleges and universities to use information technology to boost educational quality and reduce costs.

Research
One of the hallmarks of a Rensselaer education is the opportunity for intellectual partnerships between students and faculty. Particularly unique are the opportunities open to undergraduate students. During the 2002-2003 school year, 287 students participated in the Undergraduate Research Program in which students in all four class years took part in formal research.

Graduate students are involved in myriad projects from the development of “smart” materials and manufacturing processes to exploring the social and humanistic effects of technology.

Rensselaer’s research ties are national and international with experiments conducted at the Saclay Laboratory in France, the Bates Accelerator, the National Radio Astronomical Observatories, Sandia, the U.S. Geological Survey, and the National Laboratories in Brookhaven, Los Alamos, and Oak Ridge. In the last year, Rensselaer’s total research funding exceeded $58 million.

Locations
Rensselaer’s historic main campus sits on a bluff overlooking the city of Troy, N.Y., and the Hudson River. The area offers a relaxed lifestyle with many cultural and recreational opportunities, with easy access to the high-energy metropolitan centers of the Northeast.

Troy is 10 miles northeast of Albany, New York’s capital, and 150 miles north of New York City. The area is centrally located with easy access to Boston (3 hrs.), Montreal (4 hrs.), and Niagara Falls (5 hrs.). Troy and the Capital Region (population 873,500) are home to many well-known colleges such as Albany Medical College, Russell Sage, Siena, Skidmore, Union, University at Albany (SUNY), and the nearby Williams College.

The area offers a variety of recreational and social opportunities. The Adirondacks, the Berkshires, and the Catskills, all within an hour of Troy, offer hundreds of areas for camping, hiking, and skiing. Many clubs sponsored by the Rensselaer Union take full advantage of these natural resources.
Arts organizations of every description are also found in the area. The Troy Savings Bank Music Hall, considered by many experts to have the finest acoustics in America, is a short walk from campus as is a new downtown arts center. Nearby Saratoga Springs is the summer home to the New York City Ballet, the New York City Opera, and the Philadelphia Orchestra. Albany’s Pepsi Arena hosts a wide array of top-name musical groups, sporting events, and other entertainment options.

Rensselaer at Hartford is housed in its own eight-story building on 14 landscaped acres in downtown Hartford, Conn., readily accessible from both Interstates 84 and 91. Regional sites also exist in southeastern Connecticut, northern Virginia, and Malta, NY.

Facilities

Rensselaer’s 260-acre Troy campus and its several off-site facilities provide diverse environments for learning and living. From the George M. Low Center for Industrial Innovation, with its manufacturing high bay laboratories and meeting rooms, to the Adirondack site of the Darrin Fresh Water Institute, Rensselaer’s facilities support the needs of researchers and students.

The 15 major interdisciplinary research centers and several smaller ones, the Incubator Center for start-up high-tech companies, and the nationally known Rensselaer Technology Park offer undergraduate and graduate students a wide range of opportunities for research and learning through interaction with business, government, and industry.

Rensselaer’s nearby Technology Park houses more than 50 companies and 2,300 employees. The Incubator Center, recently named Business Incubator of the Year, nurtures some 28 startup companies. Two-thirds of the company owners and staff are Rensselaer faculty, students, or graduates.

Rensselaer’s Mobile Computing Program, requiring all undergraduate students to own laptop computers, has received resounding praise. Students have anytime/anywhere mobile access via more than 8,000 data ports on campus. Additionally, the top two floors of the Student Union accommodate wireless computing. Most of Rensselaer’s major computing facilities are open 24 hours a day; a Help Desk is open during business hours, and the Division of the Chief Information Officer supports student and faculty needs. It is hard to find a classroom that has not been fitted or retrofitted for the computing needs of the 21st century.

The academic library system is one of the first in the nation to have integrated a broad range of electronic features into its online systems. Users can consult the catalog, order copies of articles, renew books, and read files of campuswide information such as job openings and grant opportunities at computer terminals on and off campus. The Rensselaer libraries contain more than one-half million books, reports, and documents, as well as more than 7,000 titles of print and electronic journals.

Institute residence facilities house up to 2,900 single students and 93 student families in a variety of living environments. Indoor and outdoor athletic facilities include the Houston Field House, which is home of the NCAA Division I Engineers ice hockey team. The Mueller Center, a $6 million, 32,000-square-foot fitness center, houses more than 40 pieces of aerobic exercise equipment.

The mission of Rensselaer at Hartford is to anticipate and respond to the needs of individuals and organizations through the implementation of high-quality educational programs for working professionals. In support of this mission, Rensselaer at Hartford provides conference facilities suitable for small and medium-sized programs accommodating from 10 to 100 participants. Rensselaer at Hartford’s conference facilities are ideal for meetings and seminars for corporate, nonprofit, and government organizations, as well as professional associations. Amenities include on-site security; free, lighted parking; bookstore; and cafeteria. Rensselaer has also been serving students and corporations in southeastern Connecticut since 1977.
Alumni
Rensselaer’s more than 85,000, including Hartford, living alumni are active and influential in all facets of society. They are engineers, physicians, attorneys, architects, writers, inventors, and entrepreneurs. By contributing to scholarships and sharing their expertise with Institute leadership, they significantly enhance campus life.

The Office of Alumni Relations, supported by the Rensselaer Alumni Association, seeks to create and sustain mutually beneficial relationships among current students, alumni, and the Institute. A full range of services are offered, including career assistance, regional and campus events, affiliate group programs, print and Internet communications, sports programs, and more. Student programs include the Red and White service organization, regional “fairs,” alumni speakers, and mentoring programs.

Accreditation
Rensselaer is accredited by the Middle States Association of Colleges and Schools and by a number of professional and academic societies. Undergraduate degree programs in chemistry are certified by the American Chemical Society; professional programs in architecture are accredited by the National Architecture Accrediting Board. The Lally School of Management and Technology is an accredited member of the Association to Advance Collegiate Schools of Business, an international accreditation. All engineering bachelor’s degree programs are accredited by the Engineering Accreditation Commission of the Board for Engineering and Technology. The exception is engineering science, which is not intended as preparation for professional engineering practice.

Rensselaer at Hartford is accredited by the Middle States Association of Colleges and Schools, by the Board of Governors for Higher Education of the State of Connecticut, and by a number of professional and academic societies. Rensselaer at Hartford’s Lally School of Management and Technology is an accredited member of the Association to Advance Collegiate Schools of Business.

Rensselaer admits qualified students without regard to age, race, color, gender, sexual orientation, religion, national or ethnic origin, veteran status, marital status, or disability.

Why Not Change the World? The Rensselaer Plan
The Rensselaer Plan—the Institute’s new strategic plan—serves as the driving force to achieve new prominence for the Institute in the 21st century. This comprehensive plan defines Rensselaer’s core enterprises and sets forth the Institute’s goal to double its doctoral program and virtually triple its research initiative with special focus on biotechnology and information technology.

To fulfill The Rensselaer Plan, President Shirley Ann Jackson identified certain areas as the highest priorities of the Institute. The initiatives under way include the recruitment and hiring of faculty constellations in biotechnology and information technology; a first-year experience initiative to support the drive to attract and retain the very best students, faculty, and staff; construction of a 218,000-square-foot biotechnology and interdisciplinary studies center, expected to house approximately 400 faculty members, staff, and graduate students; and a world-class experimental media and performing arts center.
For more than 175 years, Rensselaer has offered a unique and innovative technological educational experience. As the Institute’s visionary leaders have long understood, ensuring the excellence of this experience requires learning opportunities that extend beyond traditional classroom or campus boundaries. Rensselaer’s students may choose from a broad range of distinctive advantages designed to fulfill their abundant desire for new challenges.

Especially appealing to Rensselaer’s highly motivated and intellectually talented students are opportunities to engage in leading-edge research. Rensselaer’s relatively small size enables faculty researchers to work closely with students, and they eagerly include both undergraduate and graduate students in their research work. Such opportunities are available to students in virtually every major offered through Rensselaer’s five schools—Engineering, Science, the Lally School of Management and Technology, Architecture, and Humanities and Social Sciences.

Additional special opportunities include a variety of domestic and overseas student exchange programs, internships, and real-world work experience through the Cooperative Education Program. Rensselaer’s portfolio in Education for Working Professionals also offers a highly successful distributed delivery program that extends graduate courses, certificates, and degree programs to students at many leading global corporations. Conversely, the Vollmer W. Fries and other lecture series bring leading industrialists, governmental officials, authors, and outside educator-scholars to the Troy campus.

Recognizing the benefits of such beyond-the-classroom educational opportunities, leading industries and graduate and professional schools throughout the nation actively seek Rensselaer graduates.

**Undergraduate Programs**

**Dean:** Gary A. Gabriele

Undergraduate programs leading to the Bachelor of Science degree are available in more than 30 fields listed on the inside of the front cover of this catalog. All B.S. programs are normally completed in four academic years. Dual majors are also an option that generally can be completed within four academic years. For information on general degree requirements, refer to the Academic Information section of this catalog. The individual school sections provide detailed information on the specific curricula that each offers.

The Schools of Architecture and Engineering also offer professionally accredited degrees. These are the five-year Bachelor of Architecture degree program and the four-year Bachelor of Engineering degree program. See the School of Architecture and School of Engineering catalog sections for more detailed information.

Additional special options available to undergraduates are described below.
Undergraduate Research Program
As a globally active research university committed to providing student research opportunities, Rensselaer offers undergraduates the opportunity to participate in research projects through the Undergraduate Research Program. This program offers students real-world, hands-on research experience. Students work directly with a faculty member on a bona fide research project for which they can earn either pay or course credit. There is a special summer program as well, in which the students can compete for funding that will allow them to spend a full summer working on a research project. Details on the program and titles of past projects are available at http://www.rpi.edu/dept/urp/ or in the Office of Undergraduate Education, Walker Lab, Room 4010.

Exchange and Study-Abroad Programs
Studying abroad can broaden students’ cultural horizons and offer a new and extended perspective on a technological education. Rensselaer, therefore, offers a wide variety of exchange and/or study-abroad programs to undergraduate students.

Most exchange programs are intended for students in their junior year. Students apply to participate in these programs during the second semester of their sophomore year. Serious consideration for these programs generally requires that students achieve and maintain a GPA of 3.0 or better.

Study-abroad programs with a number of established colleges and universities throughout Europe, as well as with a limited number of Asian and Australian institutions, are available. Participation in these programs is usually for one year. However, some one-semester arrangements are possible. Some programs give priority to specific majors, and some institutions require foreign language proficiency. Detailed information on study-abroad or exchange programs that individual Rensselaer schools administer can be found within the catalog section devoted to the associated school.

A comprehensive list of Rensselaer study-abroad and exchange programs and the associated contact person is provided below.

- Undergraduate International Exchange Program
  Robert Conway, (518) 276-6822, conwar@rpi.edu

- International Management Exchange Program
  Beth Macey, (518) 276-6585, maceyb2@rpi.edu

- Architecture Exchange Program
  Lecia O’Dell, (518) 276-8478, odelll@rpi.edu

- Global Engineering Education Exchange (Global E³) Program
  Lester Gerhardt, (518) 276-6203, gerhal@rpi.edu

- Swiss Exchange Program
  William A. Wallace, (518) 276-6854, wallaw@rpi.edu

- French Exchange Program
  Lucien Gerber, (518) 276-8125, gerbel@rpi.edu

- University of Amsterdam Exchange Program
  David Nichols, (518) 276-2601, nichod3@rpi.edu

Preprofessional Programs
The baccalaureate program in a number of fields in the Schools of Science and Engineering will prepare Rensselaer students to receive secondary school (grades 7-12) teacher certification from New York State. These courses of study must be done in partnership with several local colleges which have New York State
registered teacher education programs. If a decision is made early enough in a Rensselaer student’s undergraduate career, then courses can be taken at several local universities leading, upon graduation, to a Rensselaer degree in the student’s chosen major, together with preliminary teacher certification. Students who are too far along in their Rensselaer education may obtain certification through a fifth year at other institutions. For further information, students should contact Lester Rubenfeld, the director of the Center for Initiatives in Pre-College Education, at rubenl@rpi.edu.

**Prehealth Programs** Rensselaer successfully prepares students to enter medical and other health professional schools. These students major in such fields as biology, chemistry, biomedical engineering and other engineering programs, mathematics, physics, or psychology. With their adviser, these students develop a plan of study that allows them to fulfill professional school prerequisites while earning their B.S. degree. For further information, students should refer to the Prehealth Web site: [http://bio.bio.rpi.edu/MED/](http://bio.bio.rpi.edu/MED/) or contact members of the Prehealth Professions Committee located in 1W14 Science Center, (518) 276-8427.

Accelerated programs that permit students to complete undergraduate and professional studies within an abbreviated period of time are also available. For further information, see the School of Science section of this catalog.

**Prelaw Programs** The baccalaureate program in a number of fields will prepare Rensselaer students to enter law school. Rensselaer graduates who obtain law degrees are equipped to enter general practice or to serve in important legal positions in business, industry, or government. In cooperation with Albany Law School and Columbia University Law School, Rensselaer has also developed accelerated programs that permit students to earn law degrees within six years. After a three-year accelerated undergraduate program, the student enters law school. Upon completion of the fourth year, the student receives the B.S. degree. The J.D. is awarded at the end of the sixth year. See the Science and Technology Studies program within the School of Humanities and Social Sciences section and the Lally School of Management and Technology section of this catalog for further information.

**Internship Program**
Upper-level undergraduates may enroll for course credit in this program, working as volunteers for at least 80 hours per semester. Students are placed with nonprofit or governmental organizations, including Troy city government offices, local schools and after-school programs, hospitals, museums, homeless shelters, environmental organizations, the New York State Legislature, the Attorney General’s office, and others. Such internships give students a glimpse of career options in the public and not-for-profit sectors. For further information visit [http://www.rpi.edu/~interns/](http://www.rpi.edu/~interns/) or contact Nancy Campbell, Department of Science and Technology Studies, (518) 276-6065.

**First-Year Courses**
Rensselaer offers special courses or course sections in first-year subjects designed to accommodate the diverse backgrounds and preparations of entering first-year students. These include special course sections for advance placement or honors students, and for students who require extra help. Students are usually admitted to advanced or extra-help sections by invitation, and are usually identified before the start of or during the fall term.

Advanced courses permit students to continue subjects in which they have received advanced-placement credit. Extra-help sections address the needs of students with background deficiencies in specific subjects. These sections cover the same content as regular sections, but class size is limited. They also meet an extra hour each week to allow for increased individual attention from the instructor.
Reserve Officer Training Corps
Reserve Officer Training Corps (ROTC) programs are available on an elective basis for students desiring commissions as officers in the armed forces. ROTC programs are undertaken concurrently with baccalaureate degree studies.

Graduate Programs
Office of Graduate Education
Vice Provost and Dean: Tom Apple
The Office of Graduate Education at Rensselaer provides current graduate students with the administrative, academic, and curricular information they need to progress through their courses and programs. This includes assisting in changes to student degree status and advising on thesis, registration, and graduation issues, and providing approvals and processing for withdrawals, academic dismissals, and leaves of absence. The office closely monitors the effectiveness of graduate education policies and recommends and institutes adjustments to improve program quality. Online information and forms can be located at the Office of Graduate Education homepage at http://www.rpi.edu/dept/grad/gradschool.html

All doctoral programs and many master’s programs involve students in research activities that generally are supported by government, industry, or foundations. Faculty members serve as senior investigators for a wide range of challenging research projects and are assisted by postdoctoral investigators and graduate students. Research opportunities for graduate students are also an important part of many Rensselaer research centers. These centers include the Scientific Computation Research Center (SCOREC), the Center for Integrated Electronics (CIE), the New York State Center for Polymer Synthesis, the New York State Center for Automation Technologies, the Rensselaer Nanotechnology Center, and the Severino Center for Technological Entrepreneurship. Additional information about these centers can be found in the Research Resources and Centers and several other sections of this catalog.

In addition to graduate students working full-time at the Troy campus, more than 2,000 working professionals seek degrees on a part-time basis through Rensselaer at Hartford and distributed sites.

Education for Working Professionals
Vice President and Dean, Rensselaer at Hartford: Alan C. Eckbreth
Education for Working Professionals (EWP) is one of Rensselaer’s four core enterprises and encompasses a range of programs designed specifically for current and future workforce leaders with a range of high-end, customized degree, certificate, and professional development programs. Program content flows from the heart of Rensselaer’s research strengths and unique academic programs. The EWP organization supports the Rensselaer vision by forging strategic partnerships with businesses, governments, universities, and innovative professionals who impact society and technology around the nation and the world.

Rensselaer’s educational enterprise for working professionals is dedicated to providing a highly interactive learning environment for students who are seeking high-level knowledge while they hone their analytical capabilities and leadership skills and enhance their innovative thinking. The intent is to have Rensselaer graduates—executives, senior professionals, managers, and individuals with high potential—become architects of their futures. With dramatic increases in the rate of change, working professionals expect and demand an academic environment that fits the evolving needs of their fast-paced world.

Rensselaer at Hartford
Rensselaer at Hartford, a branch campus of Rensselaer Polytechnic Institute, provides a challenging edu-
EDUCATION FOR WORKING PROFESSIONALS

Rensselaer at Hartford offers graduate programs in Business Administration, Management, Computer Science, Computer and Systems Engineering, Electrical Engineering, Engineering Science, Mechanical Engineering, and Information Technology. Specialized programs include the Dual Master’s Degrees, the Weekend MBA, the Weekend M.S., and the Executive Master’s Program, as well as several graduate certificates in Bioinformatics, Computer and Information Sciences, and Engineering. Courses are delivered by faculty with significant industry experience, solid academic credentials and scholarship, and exceptional teaching skills whose expertise is grounded in sound research and best practices on a global basis. Each course is designed to meet the needs of working professionals seeking to advance their careers and enhance their organizations’ successes. Rensselaer graduates are entrepreneurial and personify the Institute’s slogan, “Why not change the world?”

Distance Delivery
For the past 15 years Rensselaer has pioneered the application of state-of-the-art technologies to deliver high-quality, interactive learning experiences in distributed environments. Rensselaer is a leading provider of graduate-level, distributed education programs for working professionals at leading corporations and government agencies all over the world. Approximately 800 students participate annually in Rensselaer courses, certificates, and degree programs from their workplace, at home, or on the road using a range of distributed delivery technologies, including satellite broadcast, videoconferencing, mailed videotape, CD-ROM, and online technologies. Distance courses originate from Rensselaer’s Troy or Hartford campuses and are supported by course Web sites and other means that provide communication and collaboration tools to facilitate interaction between students and faculty and among students. Rensselaer is known for excellence in content, delivery, and services, and has received considerable national recognition and numerous awards. Degree and Certificate programs in Engineering, Science, Information Technology, Management, and Technical Communication are available via distance.

Regional Site in Northern Virginia
Rensselaer operates a regional site in the Northern Virginia/Washington, D.C. area. From the Northern Virginia site, students may participate in Rensselaer classes that originate on the Troy or Hartford campuses via videoconferencing technology, enabling them to engage real-time with faculty and other students in the class. Courses are also available to students in the Northern Virginia area via online delivery. Graduate degree programs delivered to the Northern Virginia Site via videoconferencing include the M.S. in Management and the M.S. in Information Technology. Other degree and certificate programs are available via online delivery.

Regional Site in Southeastern Connecticut
Rensselaer operates a regional site in Southeastern Connecticut. Many faculty from Rensselaer’s Hartford campus travel to the Southeastern Connecticut site to teach courses. On-site courses are supplemented with distributed delivery of courses from Rensselaer’s Troy and Hartford campuses via videoconference delivery. Online courses are also available to students. Many of the degree and certificate programs available on the Hartford campus are also available at the Southeastern Connecticut site.

Navy Nuclear Program
Rensselaer operates a regional site in Malta, N.Y. for graduates of the Navy Nuclear Power Training School who are stationed at the Kesselring site in West Milton, N.Y. Navy personnel enter the program with one year’s worth of undergraduate coursework and Rensselaer provides the remaining course work for stu-
Educational Programs and Resources

Rensselaer students are encouraged to complete a B.S. in Nuclear Engineering, Engineering Physics, or Engineering Science within two to three years. Rensselaer courses are primarily taught onsite in Malta by faculty from the Troy campus. Onsite courses are supplemented by one or two online courses each semester.

Professional Development Programs

A full range of professional development programs are available to working professionals. Professional development programs are designed to provide working professionals with the critical skills they need to be effective in today’s dynamic workplace. Programs generally range from one day to five days in length. Training programs and workshops are available in the areas of Information Technology, Leadership and Executive Development, Quality, and Technical and Professional Development. Specialized programs reflective of Rensselaer’s research strengths are also available and will be provided in response to market demands. Services designed to help companies and individuals understand and define their developmental needs are also available. These services include needs assessment, custom program development, and executive coaching, and may be offered in multiple delivery options and locations.

Division of the Chief Information Officer

Chief Information Officer: John E. Kolb

The Division of the Chief Information Officer (DotCIO) provides information strategies, services, and technology and collaborates with Rensselaer’s diverse campus constituents to find solutions for changing educational research, communication, and business needs. DotCIO responds to the rapid evolution of distributed computing and the need for combining computing and communications services and supports Rensselaer’s nationally recognized interactive learning initiatives.

Campus computing facilities offer students a variety of software including programming language compilers, desktop publishing packages, spreadsheets, and computer-aided design packages, as well as electronic mail and conferencing.

Of the Division of the Chief Information Officer’s seven departments, students interact most closely with Academic and Research Computing and Research Libraries. Therefore, these two departments are described below. The on-line newsletter (The Kiosk) can be accessed at http://www.rpi.edu/dotcionews.

Academic and Research Computing

Director: Sharon Roy
Web site: http://www.rpi.edu/computing

Academic and Research Computing (ARC) provides educational computing services and assistance in support of Rensselaer’s learning and research activities. Computing is integrated into the curriculum and is an essential component of course work and communication.

ARC consists of 5 groups: Consulting and Research Computing, Help Desk Services, Educational Technology Services, the Campus Computer Store, and Rensselaer Computer Repair. Some of the department’s responsibilities include: administering the Mobile Computing Program, software licensing services, and the numerically intensive computing service providing consulting for researchers; maintaining the registrar-scheduled computer classrooms; and deploying software for all public computing sites. Professional staff members assist students, faculty members, and other computer users by providing specialized consulting, Rensselaer-specific documentation, and training through short courses. At the Help Desk in the Voorhees Computing Center (VCC), services can be requested from any Division of the Chief Information Officer department, and consulting help is available from the ARC staff.

As part of the Mobile Computing Program (http://www.rpi.edu/laptops), all undergraduates are required to
have a laptop computer. There are network ports in public buildings across campus and in every residence hall room. A wireless network is currently available in the VCC, the Student Union, DCC Great Hall, and several classrooms on campus, and is expanded each year.

Each student receives a Rensselaer Computing System (RCS) account that allows access to the campus network, the Internet, RPInfo (Rensselaer’s Web site), electronic mail, and library services.

Campus computing facilities offer students several platforms including PCs running Windows and UNIX. Several hundred public workstations in classrooms and labs are connected to the network. From a single workstation, personal computer, or laptop, a student can connect to several different host computers on campus as well as to off-campus host computers, data services, and networks. A variety of software is available including numeric and symbolic computation programs (Maple and MATLAB), programming language compilers (C, C++, and Fortran), desktop publishing packages and spreadsheet software (Microsoft), computer-aided design packages (SolidWorks), graphics packages, electronic mail programs, and newsreaders for Usenet electronic news. Specialized software for course work is also installed in some locations.

Some of the larger public workstation areas are located in the Voorhees Computing Center (VCC), Jonsson Engineering Center, Troy Building, Low Center for Industrial Innovation (CII), Folsom Library, and Russell Sage Laboratory. Many of these sites are open 24 hours a day and weekends, depending on the academic calendar.

For high performance computing (long-running, numerically intensive jobs), a Batch Cluster and several UNIX workstations are available. In addition, a cluster of high-performance Linux workstations can run programs that employ parallel processing.

**The Rensselaer Research Libraries**

**Director:** Loretta Ebert

The Rensselaer Research Libraries, comprised of the Folsom Library, the Architecture Library (located in the Greene Building), and the Cole Library (supporting Rensselaer at Hartford) are well on the way to achieving their goal of becoming a model digital library. Researchers can now access over 17,000 electronic journals, browse a dozen different e-book databases, and view several image databases. A new “Virtual Reference” service places patrons, wherever they are, just a mouse click away from consulting a reference librarian, and the Institute Archives is on a fast track to creating a digitized history of the Institute.

When researchers need material not held by one of the Research Libraries, they can initiate online interlibrary loan requests or use the Connect NY service to borrow books directly from a statewide consortia holding over 3,000,000 titles. They can also borrow books in person from more than 50 regional libraries. The Libraries’ special Research Express program enables Rensselaer faculty, research staff, and graduate students to order journal articles on a fully subsidized basis directly from Ingenta, a document delivery vendor for more than 20,000 journals.

Reference & Instructional Services’ librarians with subject expertise are available to assist students and researchers personally as well as to provide specialized classes and workshops on topics ranging from “Patents as Literature” to “Research in a Digital Library.” The newest reference feature is an online information literacy tutorial tailored for undergraduates. Finally, RensSearch, the Rensselaer Research Libraries’ information gateway at [http://www.lib.rpi.edu/](http://www.lib.rpi.edu/), provides a variety of services including an online catalog, access to electronic resources, guides to services, and the latest library news.

Notwithstanding the emphasis on digital resources, the Rensselaer Research Libraries continue to be an important “place” on campus for intellectual and social nourishment. Patrons socialize and grab lunch in Folsom’s Library Café, peruse the latest best-selling fiction and non-fiction books in Folsom’s Class of ’96
Reading Room, or just relax in the Architecture Library’s bright and airy reading room. Small group meeting rooms can be reserved for collaborative work and group study. Seminar and conference rooms are available to Student Union-recognized groups. The Friends of the Folsom Library sponsor monthly “Lunch & Learn” topics in a casual setting. Folsom’s 4th floor provides breathtaking views of New York’s Capital District and the Hudson Valley. A unique stainless steel water sculpture, designed by Charles Moore, rises from Folsom Library’s third floor up through the fourth floor, creating a soothing ambience for study.

**Advising and Learning Assistance Center**

**Interim Director:** Jeannie Steigler

The Advising and Learning Assistance Center provides a unified approach to assisting students in the learning and advising process. Through a variety of services, the office provides professional and caring one-stop support for undergraduate students in their academic endeavors.

Responsibilities of this office include coordination of academic advising, primary advising of undecided and nonmatriculated students, counseling of students, provision of procedures and programs aimed at student retention, free course-specific undergraduate tutoring, provision of supplemental instruction, aiding students for whom English is a second language (ESL), and delivery of workshops on time management, study skills, and stress management.

Additionally, the Advising and Learning Assistance Center staff serve on a number of campus committees and are involved in program adjustments, curriculum changes, and academic dismissal and readmission matters. Other areas of involvement include the awarding of commencement prizes, interpreting and determining exceptions to academic regulations, and assisting students with their Curriculum, Advising, and Program Planning (CAPP) reports.

Finally, the center employs student learning assistants who reside in predominantly freshman residence halls to provide learning skills assistance.

**The Anderson Center for Innovation in Undergraduate Education**

**Director:** Bradford C. Lister

Since its inception in 1990, the Anderson Center has served as an incubator for curriculum reform and a driving force for change and innovation in higher education. In brief, the Center’s mission has been to develop, research, and support new teaching methods and technologies with the aim of improving education, both on and off campus. The Center is dedicated to extending Rensselaer’s leadership position as one of the premiere learning environments in higher education. It supports faculty involvement in educational computing, develops new techniques and facilities for interactive learning, and conducts research on cognition, learning, and the assessment of learning outcomes. Current projects encompass research on student learning styles, interaction and peer-based learning in student teams, constructivist approaches to teaching complex systems, and the use of asynchronous learning networks for on-campus instruction.

The Anderson Center facilitates faculty involvement in the renewal of undergraduate education through a series of hands-on workshops on interactive learning and an annual Colloquium on Teaching and Learning. Center staff are available for consulting on all aspects of studio teaching and educational technology. Externally, the Center hosts hundreds of visitors each year from all over the world who come to Rensselaer to learn about our teaching practices. In addition to the director, associate director, and administrative assistant, the Anderson Center employs Web developers, assessment specialists, video production personnel, and a cadre of undergraduate and graduate research assistants. Center staff have expertise in experimental design, statistical analysis, course redesign, protocol analysis, assessment of learning styles, instructional design, and Web-based multimedia development.
Institute Diversity

Interim Vice-Provost for Institute Diversity: Tom Apple
The Office of Institute Diversity serves as a campuswide advocate, liaison, consultant, and clearinghouse to enhance campus synergy among faculty, students, and staff. Part of its mission is to provide leadership and direction in creating a “seamless” diversity perspective that capitalizes on the creativity and richness of Rensselaer constituents. It is proactive in its efforts to align campus diversity initiatives with the vision and mission of the university, thereby fostering the growth of a community that embraces intellectual, geographic, ethnic, and gender diversity. Institute Diversity is located on the fourth floor of the Walker Laboratory.

Center for Initiatives in Pre-College Education
Director: Lester A. Rubenfeld, Professor of Mathematical Sciences

Program Home Page: http://cipce.rpi.edu

Realizing that for too long now the nation’s best research universities have often sat idle while our system of public school education has not met expectations, Rensselaer is taking the lead in forging new relationships which will become models for others to follow. Educators at all levels, and leaders in government, business, and the philanthropic community, are unanimous in their deep concern that students in kindergarten through twelfth grades are not being properly educated and are not ready to enter the technological workplace that awaits them. Therefore Rensselaer believes that it shares with the nation’s schools an obligation to develop and deliver a first-class education to students at all levels. It also believes that the work of this Center in pursuit of that goal can enrich its own intellectual environment, tap new sources of funding for these outreach efforts, deliver substantial long-term benefits to its admission efforts, and improve its public and community relations. To achieve its vision, CIPCE seeks to foster innovations in pre-college education that build upon Rensselaer’s strengths and traditions in pedagogy, interactive learning, educational technologies and teacher education. Its activities include:

- A graduate MS in Natural Sciences program over three consecutive summers for secondary school mathematics and science teachers.
- Professional development projects for teachers including on-site classroom support; after school workshops; and summer institutes
- The development of interactive multimedia instructional materials.
- The development and integration of robotics activities into classroom curriculum, including distance experimentation.
- The use of online and other distance learning technologies to facilitate its professional development activities.
- Cognitive research focused on how technology affects student learning.

M.S. in Natural Science

The challenges presenting themselves today in the realm of mathematics and science education are vast and complex. Never in our time has education in these areas been more vital and important. Never has it been more difficult to teach. Students in these times present much greater demands, and also potential, than their predecessors.

Getting young people excited about mathematics and science is a task that has added to the challenge of teachers. And yet, if a teacher can learn to inspire observant inquiry by infusing the curriculum with the
kind of immediacy and relevance that makes it compelling to students, the job itself will be much more fulfilling for the educator as well.

Excellent teaching of mathematics and science occurs when the teacher has a broad-based, in-depth view of content, knowledge of how to integrate it with other disciplines, and the ability to use modern instructional technologies to vitalize classroom activities.

Rensselaer’s program provides teachers with an opportunity to upgrade their qualifications and examine how their curricula can make the best use of advancing technologies. Our goal is to help secondary school science and mathematics teachers enhance their skills with new techniques, tools, and a rich body of scientific and mathematics content.
Research Resources and Centers

Vice President for Research: Arthur C. Sanderson

Research plays an integral role in Rensselaer’s vision of the technological university. The discovery and application of new scientific concepts and technologies, especially in emerging interdisciplinary fields, are core goals for faculty, staff, and students. Our research programs reach across the campus, linking together departments, schools, and interdisciplinary centers, and creating opportunities for integration of research and education. Undergraduates work one-on-one with faculty members in real-world, hands-on research as part of Rensselaer’s Undergraduate Research Program (URP). In addition, research drives technological entrepreneurship and commercialization, interfacing closely with the Rensselaer Technology Park and Incubator Center.

The Office of the Vice President for Research provides infrastructure and resource support for the development of research programs and projects. Support services are offered for faculty seeking research opportunities, research proposal and budget preparation, and guidance on research management and intellectual property policies. The Office coordinates major research themes and programs through interdisciplinary research centers. Links from this Web site offer overviews of these centers, reviews of major research projects and recent accomplishments, as well as information on research policies, guidelines, and infrastructure.

Center for Automation Technologies

Director: Harry E. Stephanou
CAT Home Page: http://www.cat.rpi.edu/

The CAT has been designated since 1988 as a Center for Advanced Technology by the New York State Office for Science, Technology and Academic Research (NYSTAR).

Interdisciplinary teams of faculty, staff, and students work closely with the Center’s industrial partners to conduct basic and applied research aimed at radical industrial innovations.

Research programs in the CAT are focused on microsystems and nanosystems technology and include topics such as precision motion control, distributed microrobotic systems, massively parallel microassembly, modular micropackaging processes, and their applications to microphotonic and microfluidic systems. State-of-the-art laboratory facilities enable the rapid prototyping of novel micromanufacturing processes.


Center for Integrated Electronics

Director: Omkaram (Om) Nalamasu
Associate Director: Toh-Ming Lu

Associate Director: Morris Washington
CIE Home Page: http://www.rpi.edu/dept/cie/

The Center for Integrated Electronics (CIE) was created to carry out industry-oriented research in electronics design and manufacturing, on-chip interconnect, and the development and utilization of electronic media. CIE emphasizes all aspects of integrated electronics and electronics manufacturing (from the chipboard-system levels) and now adds the application of electronics to create interactive learning materials which will revolutionize the way technology is used at all levels—from young child to senior citizen.
The technology areas of CIE currently include, but are not limited to, IC processing techniques, semiconductor devices, multilevel interconnect technology, optoelectronic materials and optoelectronics, broadband devices, power devices, biochips, microwave devices, terahertz devices, thermophotovoltaic devices, electronics packaging, design, modeling and simulation, design and assembly methodologies, polymer synthesis for a variety of applications, low and high dielectric constant materials, and other advanced materials, devices, and processing.

The Center’s activities range from basic and applied research and education to commercialization through partnerships with industry. A complement of about 50 faculty, 100 students, and 15 full-time research staff conduct research activities incorporating projects for specific companies, as well as longer-range programmatic efforts in fundamental areas of materials processes, design, fabrication, and characterization related to integrated electronics, electronics manufacturing, and electronic media.

State-of-the-art facilities enhance research opportunities and include a Class 100 microfabrication clean room with processing capabilities both for Si and III-V base devices/circuits, and microsystems, extensive computer resources from such companies as Apple, AT&T, DIGITAL, Hewlett Packard, IBM, and Sun, and numerous state-of-the-art processing design and characterization facilities in individual laboratories. Located on the Rensselaer campus, the CIE has immediate access to expertise in a broad range of disciplines. Participants include nationally recognized faculty from Rensselaer’s Schools of Engineering, Management, Science, and Humanities and Social Sciences. In addition, over 100 undergraduate and graduate students are supported annually through the CIE’s programs.

Major Programs

Center for Advanced Interconnect Systems Technologies  The research plan in CIE’s Center for Advanced Interconnect Systems Technologies (CAIST) focuses on finding innovative, creative, and competitive ways to maximize interconnection performance. The research involves the development of new materials, processes, simulation, modeling, and fabrication techniques for high-performance and reliable interconnections. The goal of CAIST is to investigate, test, and prototype new concepts, from the device-to-system approach, that provide attractive options for significantly upgrading the performance of interconnections into the 21st century.

Center for Microcontamination Control  The Center for Microcontamination Control is an NSF Industry/University Cooperative Research Center with Research sites at the Northeastern University, the University of Arizona, and Rensselaer. The UA site was established in 1989 and has research in high-K dielectric contamination, bacterial contamination, and ultrapure water (UPW) research. The RPI site was established in 1998 and has research in CMP and electrochemical planarization. As a sponsor, KLA-Tencor has contributed a KLA-2135 Defect Inspection Station, providing a unique capability to detect submicron defects on 8-inch patterned wafers. Northeastern University established a site in 2002 with research in nano and microscale particle removal.

Center for Power Electronics Systems  The Center for Power Electronics Systems (CPES), sponsored by the National Science Foundation and established in 1998, is a national Engineering Research Center (ERC), which envisions enhancing the competitiveness and growth of the power electronics industry by developing an integrated system approach with Integrated Power Electronics Modules (IPEMs). The goal of CPES is to improve the quality, reliability, and cost effectiveness of power electronics systems by tenfold at the end of the expected 10-year life span. Virginia Institute of Technology administers this Center; and the five-university consortium consists of Rensselaer, Virginia Tech, University of Wisconsin-Madison, North Carolina A & T, and University of Puerto Rico at Mayaguez.

Focus Center at New York  This program investigates radical alternatives and new concepts leading to new solutions that will enable the U.S. semiconductor industry to transcend known limits on interconnections that would otherwise decelerate or halt the historical rate of progress toward gigascale integration.
(GSI). This program is part of the nationally distributed Interconnect Focus Center (IFC) administered from Georgia Institute of Technology. The five-member university consortium consists of Rensselaer, SUNY-Albany, Georgia Tech, MIT, and Stanford. Rensselaer’s efforts focus on multiple layers of active devices (“3-D Chips”), optical interconnects, and fundamental materials and process characterization and modeling.

Center for Broadband Data Transport and Technology IBM Corporation endows this interdisciplinary Rensselaer center, which involves faculty from the Schools of Engineering and Science, SUNY Albany, Cornell University, City College of New York, and affiliated IBM researchers. The center’s primary mission is to conduct research in optical and electrical data transport, switching, and processing to enable future generations of information technology systems. The center is also involved in educating a new generation of students and postdocs for broadband data transport science and technology. The center operates the Internet Accessible Remote Laboratory (visit http://nina.esce.rpi.edu/shur/broadband).


Postdoctoral Associates V. Hardikar, R. Iverson, V. Prasad, J.G. Rajagapolian

Rensselaer Nanotechnology Center

Director: Richard W. Siegel
Home Page: http://www.rpi.edu/dept/nsec

The Rensselaer Nanotechnology Center provides a major resource to advance the scientific promise represented by nanotechnology as well as providing new interdisciplinary research programs to educate new generations of students. Research areas of the Center include advanced materials and coatings, biosciences and biotechnology, nanoelectronics, and nanosystems. Nanotechnology uses clusters of molecules and atoms to make nanometer (billionth of a meter) size building blocks for new materials. These blocks have different properties than larger sizes of the same materials, such as electrical conductivity, optical properties, and mechanical strength. These materials can therefore be used for many new applications. The Center will focus on creating novel materials and devices that could create more effective drug delivery systems in the human body, result in stronger and more durable plastics, enable high capacity energy and information storage devices, and produce flame-retardant plastics for planes and automobiles, as well as other important applications.


Visiting Scholars: S. Chao, S. Curran, A. Ellis, T. Sleboda

Administrative Staff: D. Belser, H. Langley, N. Rysedorph, P. Stryjek
Scientific Computation Research Center

Director: Mark S. Shephard

SCOREC Home Page: http://www.scorec.rpi.edu/

The Scientific Computation Research Center (SCOREC) has been established as a focal point for research and development of advanced computational techniques and to provide graduate-level training in scientific computation. The goal of SCOREC is to develop high performance computing strategies that can be used to further knowledge in science and engineering to improve understanding of physical phenomena, provide new modeling and simulation techniques, and support computational experimentation.

SCOREC’s research activities are organized into faculty-headed programs. Four are focused on the development of generalized computational technologies for the advancement of multiscale systems engineering. They are the programs for adaptive scientific computations, parallel computation, automated modeling, and multiscale computational techniques. Four research programs are concerned with the development of computational techniques for specific application areas and include programs for biomechanics analysis methods, multiscale flows, nanoscale materials modeling, and device process to performance modeling.

SCOREC’s computing facilities include 64 and 48 processor parallel clusters, an 8 processor SGI ONYX2 with Infinite Reality graphics, and an extensive integrated workstation environment including Sun, SGI, IBM, and Apple workstations. An active Partners Program, currently consisting of ten governmental agencies and seven companies, supports SCOREC.

Affiliated Faculty

Research Associates
W. J. Schroeder

Research Engineers/Scientists
C. Dupre, R. Wentorf

Post Doctoral Research Associates

The Academy of Electronic Media

Home Page: http://www.academy.rpi.edu

Electronic media is an integral part of all aspects of society, yet with all the potential offered by today’s electronics and computing we have only begun to scratch the surface of how we may use technology to improve our lives. The mission of the Academy of Electronic Media (Academy) is to fundamentally challenge and expand the way electronic media impacts people, and the way people relate to electronic media and technology. The Academy combines artistic and technological expertise to investigate basic IT research in the areas of dynamic data access/utilization (e.g. animation, video, multimedia, etc.), collaborative computing environments, 2-D/3-D visualization/modeling, user I/O interactivity programming, and electronic media scalability/platform adaptation. At the Academy, developing interactive electronic media that stimulates multiple senses to better understand, visualize, and express ideas is part of daily work.

Academy Staff:
D. Millard, Director, W. Brubaker, Programming Director; K. Carlson, Production Coordinator; D. Slattery, Associate Director; J. Valerio, Project Manager; A. Yu, Systems Administrator
Rensselaer helps educate “leaders of tomorrow” by providing a robust set of student life programs and services designed to:
- facilitate academic success
- offer education and practice in leadership and followership
- encourage fitness for a lifetime of growth
- connect students to careers and the world of work
- build maturity, an appreciation of cultural diversity and expression, and a set of personal and professional goals and values.

Details on student life and services are offered in *The Rensselaer Planner and Guide to Student Life*, a publication of the Office of the First Year Experience.

**Office of the Dean of Students**

**Dean of Students:** Mark Smith

The mission of the Dean of Students Office (DOSO) is to support and assist students in the achievement of personal and academic success with an emphasis on student development, advocacy, rights and responsibilities, safety, and liability. The services and initiatives of this office include counseling, advising, and referral information; policy development and implementation; the approval and processing of excused absences, leaves of absence, and withdrawals for undergraduate students; and overseeing the Institute judicial system.

**Greek Affairs** Greek Affairs provides counseling, advising, and program development for individual social fraternities and sororities, as well as advising the Interfraternity and Panhellenic Councils. In addition, this program reviews and approves applications for recognition, is involved in policy development and implementation, and is committed to positive alumni and community relations.

**Office of Minority Student Affairs** The Office of Minority Student Affairs (OMSA) provides support services—academic, financial, personal, and career—to students underrepresented in the sciences, mathematics, and engineering professions, and/or enrolled through the Higher Education Opportunity Program (HEOP). Support services focus on recruitment (precollege initiatives), enrollment (summer programs), retention (academic initiatives, counseling, financial aid, and leadership development), and graduation (career development, graduate student support initiatives).

**International Services for Students and Scholars** International Services for Students and Scholars (ISSS) provides educational programs and consulting, arrival information, orientation programs, counseling and advising, and immigration information for Rensselaer’s international community. ISSS also serves as liaison to government agencies, sponsors, and other campus offices. All Rensselaer students and exchange visitors who are not United States citizens or permanent residents must register with ISSS.

**Disabled Student Services** Disabled Student Services (DSS) provides support services and referral information to current or potential Rensselaer students with disabilities. This service assists students in achieving access to the academic, social, and cultural programs offered on campus. Services are available to students whose disabilities may be physical/orthopedic, psychiatric, sensory (hearing, vision), or learning-related (including dyslexia, attention deficit, traumatic brain injury).
Student Conduct  Regulations governing student conduct and a statement of student rights are contained in The Rensselaer Handbook of Student Rights and Responsibilities. These policies are intended to help maintain an atmosphere conducive to learning and personal growth and to make the process of education positive and successful for all members of the community. Each student is expected to obtain a copy of the current handbook and to know its contents.

First-Year Experience

Dean: Lisa Trahan
The Office of the First-Year Experience
The Office of the First-Year Experience offers a comprehensive array of programs and initiatives for both students and their primary support persons that begin before students arrive on campus and continue well beyond their first year. Programs housed within the Office of the First-Year Experience include the Navigating Rensselaer orientation program, Family Programs, Community Service Day(s), the Preparing the Global Citizen program and the Information and Personal Assistance Center (IPAC) along with many other community initiatives, programs, and publications designed to help students and families navigate Rensselaer.

Navigating Rensselaer
Navigating Rensselaer consists of a two-day on campus orientation session for both students and families in July and August; on-line access to informational and campus-based assistance throughout the summer, and a five-day program Navigating Rensselaer & Beyond geared toward familiarizing students with the campus and surrounding areas while at the same time getting them connected with classmates just before the start of classes.

Student Orientation is designed to aid new students in their transition, integrate them into the life of the Rensselaer community, and introduce these students to the broad opportunities available at Rensselaer. Essential components of the orientation program include an introduction to the academic and student life opportunities for new students to interact with faculty, staff, and continuing students; and the opportunity to meet with an academic adviser and register for classes. The orientation process also includes a component that is designed to provide information to the immediate support group of each student (e.g. parents/guardians, spouse, etc.) who play an important role in the life of a new student.

After their Orientation students are encouraged to stay connected to Rensselaer via the Internet. The www.rpi.edu/fye website is an excellent way to build upon the knowledge, confidence and friendships many students acquire at their student orientation session through interactive bulletin boards and answers to frequently asked questions.

Navigating Rensselaer & Beyond is a five-day program packed with fun, challenging activities, and interactive ways to connect with others, organized around three general themes: adventure/wilderness, cultural/historical, and community service. Students are assigned into their activities on campus and in the surrounding area based on personal preference, helping to guarantee that they’ll build groups of friends and get to know classmates who share similar interests.

Family Programs
Rensselaer is committed to keeping parents and families of Rensselaer students active in the campus community. All family members are encouraged to join our listserv and become active in our parents association, Parents of Rensselaer. Traditionally, Family Weekend occurs during the fall semester. It is a festive weekend and excellent opportunity for parents and families to get to know the Rensselaer community.
Career Development Center

Director: Thomas L. Tarantelli

Career Development Center Home Page: http://www.cdc.rpi.edu

The Career Development Center (CDC) helps students take charge of and manage their career development. The CDC offers a comprehensive program of career development, co-op, internship, and job placement activities to both undergraduate and graduate students. Rensselaer students have 24-hour access to many career services and resources via the World Wide Web.


Co-op Program Rensselaer's optional co-op program, which is open to both undergraduate and graduate students, provides an excellent vehicle for students to gain critically needed work experience while still in college. More than 650 students were enrolled in Co-op in 2001-2002, working for leading employers such as General Electric Company, United Technologies, and Pitney Bowes & Pfizer. The vast majority of co-op students obtain their jobs through the Career Development Center and can apply for a wide variety of positions across the country.

Athletics

Director: Ken Ralph

Athletics are an integral part of Rensselaer life. Varsity sports, intramurals, and athletic clubs provide students with an opportunity for instruction in sports for physical fitness, recreation, and development of leadership/followership skills.

Intercollegiate Sports Rensselaer fields intercollegiate teams in 23 sports:

- **Baseball** Karl Steffen, head coach
- **Men's Basketball** Mike Griffin, head coach
- **Women's Basketball** John Greene, head coach
- **Men's and Women's Cross-Country** Colin Tory, head coach
- **Field Hockey** Bridget LaNoir, head coach
- **Football** Joe King, head coach
- **Golf** Dave Lewis, head coach
- **Men's Ice Hockey** Dan Fridgen, head coach
- **Women's Ice Hockey** Bill Cahill, head coach
- **Men's Lacrosse** Tom Korrie, head coach
- **Women's Lacrosse** Leslie Kachadourian, head coach
- **Men's Soccer** Adam Clinton, head coach
- **Softball** Erica Lewis, head coach
- **Men's and Women's Swimming** Shannon O'Brien, head coach
- **Men's and Women's Tennis** Carol Pillsworth, head coach
- **Men's Indoor and Outdoor Track** Colin Tory, head coach
- **Women's Indoor and Outdoor Track** Colin Tory, head coach
Women's Soccer

Leslie Kachadourian

The men’s hockey team competes at the Division I level and in the Eastern College Athletic Conference (ECAC) hockey league. The remaining teams play in Division III. In three sports, Rensselaer also fields junior varsity teams. Rensselaer is a member of the National Collegiate Athletic Association, the ECAC, NYSWCAA, and the Upstate Collegiate Athletic Association.

The department trains and employs student trainers, lifeguards, and equipment room attendants. Several varsity teams sponsor student managers that assist in all matters of team operations.

Athletic Clubs

Club sports sponsored by the Rensselaer Union include offerings such as Aikido Karate, Archery, Badminton, Ballroom Dance, Bowling, Cheerleading, Chung Do Kwan, Crew, Cricket, Cycling, Equestrian, Fencing, Gymnastics, Isshinyu Karate, Judo, Juggling and Unicycling, Outing Club, Racquetball, Rugby, Sailing, Scuba, Ski Club and Team, Squash, Table Tennis, Tae Kwon Do, Tennis, Ultimate Frisbee, Volleyball, Water Polo, Weightlifting, and Wrestling.

Intramural and Recreational Program

An extensive intramural athletic program offers competition in 20 sports: basketball, billiards, bowling, golf, gym hockey, ice hockey, indoor soccer, soccer, softball, swimming, tennis, touch football, track, badminton, aerobics, water polo, baseball, wallyball, wiffleball, and volleyball. Two intramural leagues are subdivided into as many divisions as necessary to accommodate all who are interested and to provide a level of competition commensurate with abilities. Recreational opportunities of all descriptions, either planned or unstructured, are available to all students.

Facilities

Rensselaer’s athletic fields include five illuminated for practice after dark and one with seating for 3,000. The Ned Harkness Field and Track, a synthetic turf field and track, was opened in 1994.

The ’87 Gymnasium contains two general-purpose gymnasiums, a swimming pool, seven four-wall combination handball and squash courts, a weight room, an indoor track, and a wrestling room. The Rensselaer Alumni Sports and Recreation Center houses the Robison Gymnasium, which has an indoor track; a physiotherapy room; basketball, volleyball, and tennis courts on a resilient surface; and locker facilities. The Robison Pool has eight lanes for competitive swimming as well as three-meter and one-meter diving boards. The Houston Field House has an ice rink, locker and team rooms, and permanent seating for 5,300 spectators. The Mueller Center, housing cardiovascular, weights, aerobics, and other fitness activities, opened in 2000.
The Rensselaer Union

Director: Richard M. Hartt

Every enrolled activity fee-paying student is a member of the Rensselaer Union, a self-supporting and self-governing body that controls, finances, and organizes student activities.

The Union recognizes 130 service, media, religious, performing and visual arts, multicultural, athletic, and extracurricular clubs and organizations. The Union serves as a partner in intramurals and intercollegiate athletics, providing operating budgets for all varsity programs. Students are also responsible for the business operations of the Union, including the University Bookstore, a convenience food store, Post Office substation, a full-service bank, and a number of other retail operations. The Union also works with student organizations to identify and carry out projects that benefit the greater Troy community.

Student leaders at Rensselaer are elected in an all-campus student election each spring. The offices of Grand Marshal, established in 1866, and President of the Union, established in 1891, are the two most responsible positions. An Executive Board of students makes major budget decisions for the Union. The Student Senate is the chief legislative body for student government and draws representation from the entire student body.

The Archer Center for Student Leadership Development

Director: Linda McCloskey

The Archer Center for Student Leadership Development provides leadership education for the Rensselaer students and community both in and outside of the classroom. The Center enhances students’ leadership skills through a variety of cutting-edge, interactive learning experiences that include adventure-based initiatives, corporate training techniques, and other methods. Archer Center programs provide every student with the opportunity to gain key leadership skills in areas such as team development, visioning, effective communication, ethical decisionmaking, and multiculturalism.

The Archer Center offers custom-designed workshops for student organizations, manages the Professional Leadership Program, facilitates the Lifeskills course, works with faculty across campus to develop interactive formats for classes and laboratories, and coordinates many other special events. Additionally, the Archer Center teaches a required course sequence in the Lally School of Management and Technology and a required Professional Development course sequence in the School of Engineering. Student groups, faculty, staff, administrators, and local communities benefit from Archer Center programs. Corporate representatives work with the Archer Center by funding some of its programs and/or speaking in leadership classes, at workshops, conferences, and at the recognition banquet.

The Archer Center for Student Leadership Development, with help from its colleagues and corporate partners, is dedicated to promoting practices that foster teamwork and integrity in the professional and personal lives of tomorrow’s leaders.

Religious Affairs

Coordinator: Edward Kacerguis

Rensselaer has a combination of resident and part-time chaplains who represent major faiths and work with the appropriate student organizations: the Rensselaer Christian Association, B.A.S.I.C., the Rensselaer Newman Student Fellowship, Hillel, and the Islamic Student Organization. All chaplains are available for personal counseling regardless of the beliefs of the individual.

The Rensselaer Newman Foundation and the Catholic Chaplaincy offer all the services of the usual parish and operate the Chapel and Cultural Center (C+CC). The Protestant Chaplain (who works with the
Troy Area United Ministries), the local rabbis, and an imam on campus seek to involve students in the life of the local churches, synagogues, and mosques.

The Catholic Chaplains conduct mass daily and four times on weekends when classes are in session, and the Protestant Chaplain holds services on nights chosen by the students. The Rensselaer Christian Association gathers each Friday for song, prayer, and sharing, and in small groups daily. The Rensselaer Newman Student Fellowship organizes varied activities and speakers. Hillel is a focal point for the Jewish student community, gathering for their activities throughout the year. The Islamic students meet throughout the day for prayer as well as on each Friday for Sabbath. A number of churches, synagogues, and mosques in the area welcome students to their communities.

**Residence Life**

**Director:** Peter G. Snyder

Approximately 55 percent of the undergraduate student body lives in campus housing. Options vary from apartments to traditional double and triple rooms in residence halls.

Institute policy requires that all noncommuting single first year students live on campus and participate in a Platinum, Diamond, or Gold dining plan. Single upperclass and graduate students may choose to live either on or off campus, to join a dining plan, or to cook for themselves. Students selecting Burdett Avenue Residence Hall housing are required to enroll in either the Platinum or Diamond dining plan.

Rensselaer’s Family Student Housing community is home to 93 families who reside in two individually styled apartment complexes. A closely knit and culturally diverse community, the family housing area offers plenty of green space and play areas, a community center, and access to campus and community resources.

Residence Life is the focus for student housing programs related to living and dining at Rensselaer. In addition to providing clean, comfortable, and well-maintained residence halls and apartments, Residence Life strives to build a community that values the potential of each individual and encourages students to broaden their perspectives, enhance personal growth, and prepare for life beyond Rensselaer. A student staff of resident assistants, resident directors, apartment managers, and learning assistants complements the professionals in the Residence Life office.

**Rensselaer Dining Services**

**General Manager:** John Fusco

Rensselaer Dining Services, managed by the Sodexho Campus Services, offers an innovative dining program designed to meet the diverse dining needs of the Rensselaer community. Meal plans range from unlimited meals anytime, in any resident dining hall, to those with unlimited meals within specified hours or days. Students may also use Mealplan Advantage Dollars (MAD) at all resident dining halls and other Sodexho Campus Services managed facilities on campus as well as Rensselaer Advantage Dollars (RAD), which can also be used at nondining services food outlets such as Father’s and Pizza Delivery Service.

Students with special dietary concerns for religious, health, or personal reasons may make arrangements to meet with the dining services to see how their needs can be met. Rensselaer does not operate a kosher kitchen but can offer frozen kosher dinners to any resident student who requests them. Dining services also offers packaged kosher foods daily and prepares a fresh kosher dinner once a week during the school year. Bag lunches are available for any meal plan participant who cannot attend a regularly scheduled meal due to class schedule conflicts by bringing his or her class schedule to the general manager or dining hall manager.

For more information, refer to our web site at www.rpi.edu/dept/dining.
Student Health Service

**Director:** Robert B. Athanasiou, Ph.D., M.D. FACEP

The Student Health Center is a comprehensive, nationally accredited, physician-directed program providing outpatient ambulatory health care. Services include medical, gynecology, and allergy clinics, a counseling center, and health education and wellness programs. Specialty consultation referral and a prescription delivery program are also available.

The Student Health Center is fully certified by the Accreditation Association for Ambulatory Health Care (AAAHC). The AAAHC is an independent national organization that evaluates the quality of care at ambulatory centers such as outpatient surgery centers, clinics, and college health centers. Rensselaer’s commitment to seek and maintain AAAHC certification provides assurance of the quality of patient care and the appropriate organizational framework for providing care.

The Counseling Center offers individual counseling sessions and group workshops for personal and academic adjustment problems. Confidentiality is strictly maintained except when a student’s behavior presents a clear and present danger to the student or to others.

Located on the Troy campus, the Gallagher Student Health Center is open Monday through Friday from 8 a.m. to 6 p.m. and from 1 p.m. to 5 p.m. on weekends during the academic semesters. Summer session and vacation hours are more limited. A 160-bed community hospital with a 24-hour emergency department is located two blocks from the campus.

All matriculated students pay a Health Center Fee that provides access to the Student Health Center during each regular semester (see Tuition and Fees section). This is a mandatory fee that is not waivable. Coverage for summer sessions is included in the spring semester fee.

Rensselaer students are required to have adequate health insurance. The Rensselaer Student Accident and Sickness Insurance Plan uses a low-cost Preferred Provider Organization (PPO) that provides nationwide year-round coverage at a very reasonable cost (see Tuition and Fees section). This insurance plan, together with the services of the Student Health Center, provides seamless coverage for students while at school. The plan also meets J-1 visa requirements. Dependent coverage is available at reasonable cost. Students who have equivalent health insurance that provides nonurgent coverage in Troy, may request waiver of the PPO plan.

All students, including part-time students, must submit a medical history and record of physical examination on a form provided by Rensselaer. No other form can be accepted. Students must show adequate evidence of meeting Rensselaer and New York prematriculation immunization and tuberculosis screening requirements.

Student Records and Financial Services

**Director:** Sharon F. Kunkel

This office combines the activities of the registrar and the financial aid office to provide seamless services to students, families, alumni, and Institute faculty and staff.

Student Records and Financial Services registers, provides advising support, awards and administers financial aid resources, and manages accounts for all Rensselaer students. This office maintains accurate student academic and financial records and preserves the confidentiality, security, and ethical handling of these records. It implements academic policy guidelines developed by the faculty as well as financial policies set forth by federal, state, and Institute guidelines.
Undergraduate Admissions

Dean of Enrollment Management: Teresa Duffy

Contacting Rensselaer Admissions
Information and application forms are available by contacting:
Office of Undergraduate Admissions
Rensselaer Polytechnic Institute
110 8th Street
Troy, New York 12180-3590
Phones: (518) 276-6216
Western regional office: (760) 730-3132
E-mail: admissions@rpi.edu
World Wide Web: http://admissions.rpi.edu

Undergraduate admission to Rensselaer is outlined briefly below. Detailed information is provided with freshman or transfer application forms available from the Office of Undergraduate Admissions.

Rensselaer accepts the Common Application in lieu of its own form and gives equal consideration to both. Students may obtain copies of the Common Application from their high schools. Students may also apply electronically via Embark.com on the Rensselaer site noted above.

Rensselaer admits qualified students without regard to gender, sexual orientation, age, race, color, religion, national or ethnic origin, marital status, or disability.

Freshman Admission
Admission to Rensselaer is competitive. The Committee on Admissions, in evaluating the qualifications of each applicant, pays particular attention to (1) academic performance throughout secondary school; (2) results of the College Entrance Examination Board Scholastic Assessment Test (SAT I) or results of the ACT Assessment (ACT); (3) the recommendation from the applicant’s school; and (4) character and extracurricular achievements.

Students interested in Rensselaer have the option of applying to one of the five schools or as an undecided candidate. Architecture and Electronics Arts applicants must submit a portfolio.

Applications for freshman admission should be addressed to the Dean of Enrollment Management and filed by January 1 of the year in which the applicant expects to begin his or her college program. Applications should be accompanied by a $50 application fee. Regular admission candidates can expect to be notified of Rensselaer’s decision in late March.

Accelerated Programs Applicants to our accelerated physician-scientist and law programs must apply by December 1. Special requirements apply to this process. Please contact the Office of Admissions for further detail, or access Rensselaer’s Web site under the appropriate heading.

Early Decision Rensselaer offers an early decision opportunity to students who have decided definitely that Rensselaer is their first choice. An Early Decision application must be received by November 15 of the candidate’s senior year in secondary school. Students can expect to receive notification of the admissions decision by the end of December. Early Decision is not available to students applying to the accelerated programs.

Early Admission Rensselaer considers candidates who have completed all admission requirements and who wish to enter the university after the junior year of high school.

Midyear Admission Rensselaer does enroll students beginning in January. A full range of freshman courses is available during the spring semester, and the midyear entrant may pursue a degree through the tra-
ditional eight-semester timetable or accelerate through summer work. Students interested in January admission should file applications by November 1 of the preceding year. Midyear admission is not possible for the accelerated programs in medicine, law, or for the School of Architecture. Midyear admission does have some special challenges, and we cannot guarantee class availability if the fall class is a large one.

**Applying to Rensselaer**

**Academic Preparation**

In order to insure success in Rensselaer’s demanding curricula, an applicant’s academic preparation should include:

- 4 years of English
- 4 years of mathematics (through pre-calculus)
- 3 years of science (physics and chemistry preferred)
- 2 years of social studies/history

Since all applications are reviewed individually by the admissions committee, it is important to note that some differences in preparation and academic background may be considered.

Note to international applicants: Official transcripts must be translated into English and the international financial statement should be completed and mailed with the application.

**Standardized Test Requirements**

- SAT I or ACT
- SAT II Subject Tests in Math, Writing, and Science for Accelerated Program applicants only (or ACT in lieu of SAT I and SAT II)
- TOEFL for international applicants (minimum score 570 or computer-based 230)

**Portfolio**

- Architecture and Electronic Arts applicants are required to submit a creative portfolio

**Entrance Tests** Candidates for freshman entrance are expected to take the College Entrance Examination Board’s Scholastic Assessment Test (SAT I) or the ACT Assessment (ACT).

These examinations may be taken at the student’s convenience, but not later than the December test date for ACT or the January test date for College Board sponsored tests in the senior year. Early Decision applicants must complete the tests by December test date. The Admissions Committee cannot assure full consideration if tests are taken later than these dates. The student is responsible for having all test results sent directly to Rensselaer by the testing service.

**Accelerated Program Requirements** The SAT I and SAT II: Subject Tests or the ACT will be accepted in fulfillment of test requirements for students applying for the seven-year accelerated physician-scientist and six-year law programs. These students must complete the tests by the November test date. The SAT II: Subject Tests are required in mathematics, writing, and science.

**Application Fee and Admission Deposit** A $50 nonrefundable fee is required with every application to a baccalaureate program at Rensselaer. A candidate who accepts Rensselaer’s offer of admission reserves his or her place in the class by making a $300 deposit by May 1. These funds are credited toward the student’s first semester charges. If the student does not enroll, the deposit is forfeited.
Undergraduate Transfer Admission/Special Programs

Transfer students are an important part of the university community. Each year, Rensselaer enrolls more than 200 transfer students from accredited two- and four-year colleges in the United States and many other countries. Rensselaer accepts transfer students for all programs except the accelerated programs in medicine and law.

To be considered for transfer admission, a student should have earned at least 12 credit hours in the appropriate course work at another accredited college or university. Admissions requirements vary from department to department and school to school.

Transfer applicants should submit an application by June 1 for fall entrance, November 1 for spring entrance, and by March 1 for entrance to the School of Architecture. In addition to the application form, students should submit a non-refundable $50 application fee, official transcripts from all previously attended colleges, and a faculty letter of recommendation from your major department. Applicants to the School of Architecture and the Electronic Arts program must also submit a creative portfolio with their applications. Students with less than four semesters of full-time college work should also submit a complete high school record. A high school record consists of an official transcript, results of standardized tests, and a recommendation from a high school official.

Transfer admissions decisions are made on a rolling basis. Files are reviewed when they become complete and notification is sent to the student. Once a student has been admitted, the faculty will review all previous course work to determine transfer of credit. Each student will be mailed a plan of study, which outlines the course work the student must complete at Rensselaer to earn the desired degree.

In order to earn a Rensselaer undergraduate degree, a student must be registered full-time for a minimum of four semesters. Two semesters of part-time study at Rensselaer will be considered equivalent to one semester of full-time study. In addition, the student must complete a minimum of 48 credit hours at Rensselaer, all of which will be applied to the baccalaureate degree. If a transfer student elects to study abroad or enroll in the co-op program, no more than 12 such credits may apply to the 48 needed for the bachelor’s degree. The student’s plan of study at Rensselaer must include at least 16 credits of courses above the 1000 level in the major field or in an approved concentration.

The Institute requires a degree candidate to earn the last 30 credits in courses completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting towards the student’s last 30 credits and require the approval of the director of the Advising and Learning Assistance Center.

Rensselaer offers transfer students a wide range of aid options and a staff of financial aid professionals who will work with them to devise the best solutions. Students who wish to be considered for federal financial aid should complete and submit the Free Application for Federal Student Aid (FAFSA). Rensselaer’s FAFSA code is 002803.

For further information on our financial aid programs, please contact the Financial Aid office at (518) 276-6813, or e-mail them at financial_aid@rpi.edu.

Two-Year College Affiliated Program

Students graduating with an A.S. degree from a two-year or community college affiliated with Rensselaer, may transfer at the end of two years with full junior status if accepted for admission to Rensselaer.

(The schools listed below have agreements for programs in the School of Engineering. Some schools also have agreements for programs in Science (SCI), Management (MGT), Humanities and Social Sciences (H&SS), and Building Sciences (BLSC).)
Four-Year Affiliated College Engineering Program  The Affiliated College Program combines the resources of Rensselaer and a select group of affiliated liberal arts colleges and universities. This program is designed especially for students who decide during their college careers to enter the field of engineering. Students transfer to Rensselaer after completing three years of liberal arts study, including extensive and advanced course work in mathematics and science. After two or three years of concentrated study in engineering and applied science at Rensselaer, these students receive degrees from both the liberal arts college and Rensselaer.

Interested students apply for the program during the fall of their junior year on the recommendation of the liberal arts college’s pre-engineering committee. Applications are available from Rensselaer’s Office of Admissions. An official college transcript is required in addition to a letter of recommendation from the liberal arts college’s pre-engineering committee. Most students accepted for the Affiliated College Program have achieved at least a B average with grades of A or B in calculus, calculus-based physics, and chemistry courses.

A 3-2 program is offered in which a student completes three years (through the junior year) at the liberal arts college, then transfers to Rensselaer’s School of Engineering. Two years of carefully planned study complete the requirements for the bachelor’s program of the liberal arts college and the B.S. degree with a major in engineering at Rensselaer.

Institutions participating in this program are:

- Adirondack Community College, N.Y.
- Anne Arundel Community College, Md. (SCI)
- Berkshire Community College, Mass. (MGT)
- Broome Community College, N.Y.
- California Community College System, all 107 campuses (SCI, MGT)
- Canton College of Technology, N.Y.
- Cayuga County Community College, N.Y.
- Corning Community College, N.Y. (SCI, MGT, H&SS)
- County College of Morris, N.J. (SCI)
- Dutchess Community College, N.Y.
- Eri Community College, N.Y. (MGT)
- Fulton-Montgomery Community College, N.Y.
- Greenfield Community College, Mass.
- Holyoke Community College, Mass. (MGT)
- Hudson Valley Community College, N.Y. (SCI, MGT, H&SS, BLSC)
- Jamestown Community College, N.Y.
- Jefferson Community College, N.Y.
- Miami-Dade Community College, Fla.
- Mohawk Valley Community College, N.Y. (SCI, MGT, H&SS)
- Monroe Community College, N.Y.
- Montgomery Community College, Md. (SCI)
- Morrisville Agricultural and Technical College, N.Y.
- Nassau Community College, N.Y.
- Niagara Community College, N.Y.
- North Shore Community College, Mass.
- Norwalk Community College, Conn.
- Onondaga Community College, N.Y.
- Orange County Community College, N.Y.
- Rockland Community College, N.Y.
- St. Louis Community College, Mo.
- Springfield Tech Community College, Mass.
- Suffolk County Community College, N.Y.
- SUNY Agricultural and Technical College at Alfred, N.Y.
- SUNY Agricultural and Technical College at Delhi, N.Y.
- Tompkins-Cortland Community College, N.Y.
- Ulster Community College, N.Y.
- Westchester Community College, N.Y.
- Program in Science only: Schenectady County Community College, N.Y.
- The College of Saint Rose, N.Y.
- Colorado College, Colo.
- Denison University, Ohio
- Dickinson College, Penn.
- Earlham College, Ind.
- Fairfield University, Conn.
- Franklin & Marshall College, Penn.
- Gettysburg College, Penn.
- Grinnell College, Iowa
- Hamilton College, N.Y.
- Hobart and William Smith Colleges, N.Y.
- Amherst College, Mass.
- Atlanta University Center, Ga.: Clark Atlanta University, Morehouse College, Morris Brown College, Spelman College
- Bates College, Maine
- Beloit College, Wis.
- Benedict College, S.C.
- The Claremont Colleges, Calif.: Claremont-McKenna College, Pomona College, Scripps College
- Colgate University, N.Y.
- College of William & Mary, Va.
- Adirondack Community College, N.Y.
- Anne Arundel Community College, Md. (SCI)
- Berkshire Community College, Mass. (MGT)
- Broome Community College, N.Y.
Hope College, Mich.
Ithaca College, N.Y.
Kenyon College, Ohio
Knox College, Ill.
Lawrence University, Wis.
Lincoln University, Penn.
Middlebury College, Vt.
Ohio Wesleyan University, Ohio
Pace University, N.Y., all campuses
Reed College, Ore.
Ripon College, Wis.
Roberts Wesleyan College, N.Y.
Russell Sage College, N.Y.
St. John Fisher College, N.Y.
St. Lawrence University, N.Y.
Siena College, N.Y.
State University of New York College at Fredonia, N.Y.
State University of New York College at Oneonta, N.Y.
The University at Albany, N.Y.
University of the South, Tenn.
Washington & Lee University, Va.

Part-Time Matriculated Undergraduates
Rensselaer Polytechnic Institute accepts a limited number of part-time matriculated undergraduate students. Students seeking admission must meet the same academic standards (SAT scores and previous scholastic records) as full-time entering transfer students and freshmen.

Prospective part-time students from outside the Institute and currently enrolled nonmatriculated students should apply to the Office of Admissions.

Part-time undergraduates will be assigned an academic adviser in the department of their major and must select courses from the regular day or evening course offerings at the Institute. Part-time students must pay a continuing registration fee and are subject to changing requirements given in the Rensselaer Catalog.

Part-Time Nondegree Students
Rensselaer welcomes students who wish to take one or more courses on a nonmatriculated basis for personal enrichment or professional development. Such students should contact the Office of Admissions in order to complete the necessary application procedure at least one week prior to the last day of registration before each semester. An official transcript of former academic work is required. The admissions decision is based on the student’s demonstrated academic ability, the appropriateness of the course(s) requested, and the availability of space in the course(s). Nonmatriculated students receive transcripts and full academic credit for courses successfully completed. However, only 12 hours of such credit may be applied toward a Rensselaer degree should the student later apply and be accepted for degree-seeking status.

Rensselaer also accepts a limited number of qualified secondary school students who wish to enroll in appropriate courses in conjunction with their secondary school programs. All course work receives full credit, which may be applied toward degrees at Rensselaer or other universities. Students and guidance counselors should contact the Office of Admissions for further information.

International Students
More than 200 international students representing 72 nations are enrolled in undergraduate studies at Rensselaer. Through the Offices of Admissions and International Services for Students and Scholars, Rensselaer provides special services to ensure that international students make a seamless entrance into Rensselaer’s academic community and are geared to success in their endeavors. Freshman and transfer international applicants should begin planning at least a year in advance of application deadlines.

Freshman International Applicants Submit a completed application with official copies of all academic transcripts for secondary school, with English translations; official results of SAT I exam; and results of the TOEFL, if English is not your native language or if your SAT Verbal score is below 580. For students who will study on an F-1 or J-1 visa, evidence of financial support to cover educational and living expenses is also required. Architecture and Electronic Arts applicants are required to submit a portfolio. All first year students are required to have a laptop.
Transfer International Applicants  Submit a completed application with official copies of all academic transcripts with English translations; results of the TOEFL, if English is not the student’s native language; and a letter of recommendation from a college official. Students with less than four semesters of post-secondary study must also submit official transcripts of secondary school studies and SAT I results. For students who will study on an F-1 or J-1 visa, evidence of financial support to cover educational and living expenses is also required. Architecture and Electronic Arts applicants are required to submit a portfolio.

English Language Requirement  There are two options for international students to demonstrate their English language proficiency. These options include achieving minimum scores on one of the following testing options: 570 - TOEFL; 580 - SAT I Verbal.

Financial aid Rensselaer does not offer need-based financial assistance to international students.

Graduate Admissions

Dean of Enrollment Management: Teresa C. Duffy

Contacting Rensselaer Admissions

Information and application forms are available by contacting:

Rensselaer Admissions
Graduate Programs
Rensselaer Polytechnic Institute
110 8th Street
Troy, New York 12180-3590
Phone: (518) 276-6216
E-mail: admissions@rpi.edu
http://gradadmissions.rpi.edu

Admission to all graduate courses and degree programs at Rensselaer is based on the submission of a formal and competitive application. The applicant’s prior academic records as well as references and test scores, where required, are examined for evidence of ability to meet Rensselaer’s graduate standards and degree requirements as outlined under individual program and course description sections of this catalog.

For admission to graduate studies, a student must have a bachelor’s degree prior to enrollment, or what the Rensselaer Admissions Office determines to be the equivalent. Degree-seeking applicants may sometimes be admitted with conditions. Admission and/or continued enrollment depends on the satisfactory fulfillment of the conditions. Rensselaer admits qualified students without regard to gender, sexual orientation, age, race, color, religion, national or ethnic origin, marital status, or disability.

Graduate Student Classification

Full-Time Degree-Seeking Status  The applicant who intends to complete a graduate degree on a full-time basis is considered for regular, degree-seeking status.

Part-Time Degree-Seeking Status  Students wishing to pursue degrees on a part-time basis may do so in most departments. Admission procedures are the same as for full-time, degree-seeking applicants.

Nonmatriculated Status  The applicant who wishes to undertake graduate course work to improve his or her knowledge in a specific area but not follow a degree program is considered for nonmatriculated status. A minimum B average must be maintained to continue enrollment. The Rensselaer Admissions Office coordinates advisement and approvals for registration. However, should the student later apply for and be accepted into degree-seeking status, the number of credit hours taken as a nonmatriculated student that can ever be credited toward a degree varies by department, usually from a low of six to a university-
wide maximum of 12 credit hours. The Rensselaer Admissions Office provides additional information and applications.

**Admission Procedures**

For application forms and program information, contact the Rensselaer Admissions Office.

Prospective applicants should indicate their preferred academic area and whether they are interested in full-time, part-time, or nonmatriculated status when they inquire about admission. Applicants must submit a completed official application form and a nonrefundable $45 application fee. An applicant holding a bachelor’s degree and wishing to register for university courses as a part-time or nonmatriculated student also must apply according to these procedures.

The Graduate Record Examination (GRE) is required by most departments and is strongly recommended for applicants whose prior academic records are not clearly competitive. Submission of GRE results is especially important for applicants requesting financial aid. Complete information on individual departments requiring the GRE is sent with the admission application. Department-specific requirements is available in the admissions application or on-line at http://gradadmissions.rpi.edu.

The Graduate Management Admission Test (GMAT) is required of all applicants to the Master of Business Administration. Applicants for the Ph.D. degree in Management may take either the GMAT or the GRE General Test.

Applicants whose native language is not English must have scores from the Test of English as a Foreign Language (TOEFL) submitted directly by the Educational Testing Service, Princeton, N.J. A minimum score of 570 is required. Some departments require a higher TOEFL score and evidence of spoken proficiency. Please see the department-specific requirements in the graduate admissions application.

**Early Admission to Graduate Studies**

Rensselaer undergraduates with strong academic records may apply to the Admissions Office for graduate studies as early as the junior year. If they are considered academically qualified by the department and the Admissions Office, students may be admitted and pursue both the undergraduate and graduate degrees simultaneously. The bachelor’s degree must be completed concurrently with, or prior to, the master’s degree.

**Dual degrees**  
Many programs now offer dual degree options, especially the combination of technological master’s and the MBA degree. Please see department-specific information for dual degree opportunities. Prospective students must complete two applications, one for each department. The Statement of Background and Goals must clearly outline the interest in, preparation for, and intersection of the degree programs to which the student is applying. Letters of Recommendation must also support the dual degree intent of the student. Two application fees are required as are two sets of supporting materials, in duplicate.
Undergraduate Financial Aid

Director: James H. Stevenson

Education for leadership in the technological professions requires substantial resources. As a private university, Rensselaer meets the costs of education, laboratories and facilities, student services, and administrative support by a combination of tuition, fund raising, and endowment earnings.

While a quality education adds value well in excess of its cost, many students and families are not able to meet the cost with their own resources. Financial aid is important for most undergraduate and graduate students.

Rensselaer is committed to making a quality education financially possible for undergraduates and their families. The Institute is equally committed to making a complex process as simple and straightforward as possible.

Current and prospective students are invited to contact the Financial Aid Office, which at Rensselaer is part of the Office of Student Records and Financial Services, at (518) 276-6813.

Applying for Financial Aid

Prospective first-year and transfer students apply for financial aid by submitting only the Free Application for Federal Student Aid (FAFSA)* to the Federal Processing Center. This simple form entitles the applicant to consideration for all financial aid administered by Rensselaer, including industrial, foundation, and endowed scholarships.

Upper-class students requesting aid, whether or not they have received aid before, must submit the FAFSA and, if their application has been selected for verification, copies of their federal tax returns and their parents’ federal tax returns.

Financial Aid

Most assistance from Rensselaer is based on financial need: the difference between college costs and what student and family can be expected to pay.

College Cost  The total estimated expenditure for a Rensselaer undergraduate for the nine-month 2003-2004 academic year is as follows:

<table>
<thead>
<tr>
<th></th>
<th>Resident Students</th>
<th>Commuter Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$27,700</td>
<td>$27,700</td>
</tr>
<tr>
<td>Fees</td>
<td>796</td>
<td>796</td>
</tr>
<tr>
<td>Room and board</td>
<td>9,083</td>
<td>------</td>
</tr>
<tr>
<td>Commuting expense</td>
<td>------</td>
<td>3,570</td>
</tr>
<tr>
<td>Books and personal expenses</td>
<td>1,621</td>
<td>1,621</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$39,200</strong></td>
<td><strong>$33,687</strong></td>
</tr>
</tbody>
</table>

Family Contribution  To determine the expected family contribution, the Financial Aid Office looks at both parent and student resources. Parent contribution is determined by income and asset information provided on the FAFSA, along with the previous year’s federal tax return. Allowances are made for such factors as siblings in college, age of parents (for estimating retirement needs), and family size.

* FAFSAs can also be filed over the Internet at http://www.fafsa.ed.gov.
Aid Award  In making aid awards, Rensselaer's usual approach is to award scholarship funds first and because these funds are necessarily limited, add self-help awards (loans and work-study jobs) to help meet need. Most awards are a combination of scholarship, loan, and/or job. Students receiving combination scholarship and loan and/or job awards are not required to accept the loan or job in order to retain the scholarship.

Adjustments  Rensselaer evaluates parent and student tax returns and verifies the enrollment status of other family members in college. Awards may be adjusted when there are differences between FAFSA estimates and actual figures. If you receive scholarship aid from outside industrial, community, or other sources, you must notify the Financial Aid Office of these awards. If your federal need has not been fully met or you are receiving only merit awards, you may be able to keep the outside award in addition to our financial aid offer. However, if your need is fully met and your aid award includes federal aid, we will reduce the loan or work portion of your package first. If you should have any questions regarding how an outside award may affect your financial aid offer from Rensselaer, please contact our office.

Annual Renewals  Because family circumstances may change from year to year, need is re-evaluated annually. Students reapply for financial aid each April, and awards are returned during the summer.

Continued Commitment  If your need persists, you will continue to receive financial assistance. Moreover, Rensselaer will maintain, but not increase, the amount of Rensselaer scholarship you are receiving, provided that your need is also at the same level.

Academic Progress  Rensselaer does not tie renewal of financial aid, including the size of Rensselaer scholarships, to grades. Students with federal or New York state awards, however, must meet their satisfactory progress guidelines.

Eligibility  Undergraduate aid is continued through eight semesters (10 for students in the School of Architecture), including semesters spent at institutions other than Rensselaer. Students who require additional semesters to complete their degree because of reduced course loads, change of major, double major, failure in courses that must be made up, or other unusual circumstances are not eligible for any type of aid administered by Rensselaer.

Dependence/Independence  Under standard financial aid procedures, the student’s personal and family situation, as described in the initial application for admission, continues to be the basis for Rensselaer financial assistance for the duration of the undergraduate program. A student enrolling at Rensselaer as a dependent family member must continue to submit parental financial information as the basis for aid until the bachelor’s degree has been received. Marriage, leaves of absence, declarations of “emancipation,” or other circumstances do not alter this requirement.

Financial Aid Refund and Repayment  If, for some reason, a student cannot complete a semester, the following financial aid refund and repayment policies apply.

Refund  Rensselaer’s refund policy for a student withdrawing on or after the first day of class of a payment period is outlined in the Tuition and Fees section of this catalog. If the student received any federal Title IV funds, a portion of the refund will be returned to the programs from which the student was funded. Refunds are distributed to Title IV programs in the order prescribed by law. The non-Title IV share of the refund is distributed in the following order: state grant, institutional grant, institutional loan, private grants or scholarships, private loans, student/parent.

Repayment  When a student withdraws, drops out, or is expelled on or after the first day of class of a payment period, the Institute will determine whether the student received an overpayment of financial aid
funds for noninstitutional expenses. If the student received a cash disbursement of Title IV funds and owes a repayment, a portion will be returned to the Title IV programs from which the student was funded. The Title IV portion of the repayment will be distributed among the Title IV programs in the order prescribed by law. A student who owes a repayment on a Pell Grant or SEOG is ineligible for further Title IV assistance until the repayment is made. Full details on policy and procedures are available in the Financial Aid Office.

Financial Aid Awards
Rensselaer Scholarship Programs
To provide access to a quality education for high-quality students, Rensselaer offers substantial financial aid from its own funds. Scholarship grants are awarded after full consideration of the following factors: relative financial need, academic achievement and promise, qualities of character as suggested by recommendations submitted on behalf of the student, evidence of willingness to help oneself by working, and participation in community and school activities. Students do not apply separately for these awards.

Industrial, Foundation, and Endowed Scholarships A great many scholarships are given to Rensselaer by corporations and foundations and through the generosity of alumni and friends. Some of these scholarships are available to first-year students and continue for four years; others are available only in the upper-class years. A list of these scholarships is provided at the end of the undergraduate financial aid section of this catalog.

Rensselaer Medal This medal has been awarded by 3,000 high schools worldwide to their most promising juniors in math and science since 1916. Medallists who enroll at Rensselaer receive a substantial scholarship throughout their four years.

Federal Grants, Loans, and Work/Study Assistance
The federal government offers a number of grant, loan, and work-study programs:

Federal Pell Grant These grants, varying from $400 to $4,050, are awarded to the neediest students (based on a federal calculation).

Federal Supplemental Education Opportunity Grant (SEOG) These additional grants are made to Pell Grant recipients.

Federal Perkins Loan A need-based loan program, with a fixed interest rate of 5%. Payment of both principal and interest are deferred while the student is in attendance at least half time.

Federal Stafford Loan (Subsidized) A need-based student loan with a variable interest rate and maximum amounts of $2,625 (freshmen), $3,500 (sophomores), and $5,500 (juniors and seniors) with a maximum cumulative total of $23,000. Both principal and interest are deferred while the student is enrolled at least half time. The federal government deducts a 3% processing fee from the amount borrowed.

Federal Stafford Loan (Unsubsidized) Students who do not qualify for all or part of the subsidized Stafford Loan program may qualify for an unsubsidized Stafford Loan, that is, a loan for which the student must either start paying interest while still in school or allow the interest to accrue. Students may borrow up to the limits of the subsidized program less any subsidized loan they may already have. The federal government deducts a 3% processing fee from the amount borrowed.

Federal Work-Study Program This is a need-based program for students with very high needs. Jobs earn $7.00 per hour up to $2,000 per year.
Other Programs In addition to these general forms of student assistance, the federal government has aid programs directed to specific groups of students. Examples include the U.S. Bureau of Indian Affairs, Aid to Native Americans Higher Education Assistance Program, and Veterans Administration (VA) educational benefits. Students who may be candidates for these programs are urged to contact the Financial Aid Office.

Application Based on the FAFSA, the Financial Aid Office reviews eligibility for these programs and makes awards within program guidelines and formulas (as always, subject to available funds). Detailed information on eligibility, award schedules, distribution of funds, cancellation, and specific rights and responsibilities of recipients is available from the Financial Aid Office.

Academic Progress To remain eligible for these Title IV federal student assistance programs, students must earn a specified number of credit hours and maintain a required grade point average each year. These requirements are published annually and are distributed to recipients with their awards. Students who fail to maintain the minimum credit hours or achieve the required grade point average are placed on federal financial aid probation and have one academic year in which to earn sufficient credits or achieve the required grade point average before losing federal aid eligibility. Students denied federal financial aid for failure to make satisfactory academic progress may appeal through the Office of Financial Aid.

ROTC Financial Aid Programs
Financial assistance is available for both scholarship and nonscholarship Reserve Officers Training Corps (ROTC) students.

The former receive scholarships for periods varying from two to four years. These provide tuition ranging from approximately $4,000 to full tuition, a variable allowance for books, some fees, plus a monthly stipend. Students entering Rensselaer with certain ROTC scholarships receive an additional scholarship covering the average cost of on-campus room and board. This scholarship will be paid each year the student remains eligible for ROTC scholarship benefits and resides in on-campus housing and participates in a meal plan.

Nonscholarship students receive a monthly stipend during their junior and senior years.

Deadlines for scholarship applications vary among the Army, Navy, and Air Force. Details are available from service representatives:

Aerospace Studies (Air Force), (518) 276-6236
Military Science (Army), (518) 276-6254
Naval Science (Navy/Marines), (518) 276-6251

New York State Grant Programs
New York offers a number of financial aid programs to residents. The Tuition Assistance Program (TAP) and Higher Education Opportunity Program (HEOP) are described below. In addition, the state offers other special programs including the following for which details and application information are available at New York State Higher Education Services Corporation, 99 Washington Avenue, Albany, NY 12255:

- Regents Awards for Children of Deceased or Disabled Veterans
- Regents Awards for Children of Deceased Police Officers or Firefighters
- Regents Professional Opportunity Scholarships
- Robert C. Byrd Honor Scholarships
- Vietnam Veterans Tuition Awards
- State Aid to Native Americans
- Scholarship for Academic Excellence
**Tuition Assistance Program (TAP)** TAP awards are available to New York residents attending Rensselaer full time during the academic year (half time during the summer). They are based on New York state taxable income and vary from $500 to $5,000.

Financial aid awards to New York residents include a TAP award at a level estimated based on information provided on the FAFSA. Students, however, must complete an Express TAP application and send it to the New York State Higher Education Services Corporation, 99 Washington Avenue, Albany, NY 12255. Notification of the actual grant amount is received from this agency approximately four weeks after receiving the application.

Undergraduate students may generally receive TAP awards for four years of study. Students enrolled in approved five-year programs or in state-sponsored opportunity programs may receive undergraduate awards for five years.

To remain eligible to receive New York state financial assistance, students must earn a certain number of credit hours each semester, maintain a minimum grade point average, and achieve what is referred to as “satisfactory program pursuit.” These requirements are published annually and are distributed to recipients with their awards.

**Higher Education Opportunity Program (HEOP)** This program is open to New York state residents who matriculate at an independent college or university in New York state, and who are academically and economically disadvantaged according to guidelines approved by the Board of Regents and the director of the budget.

Application is made to Rensselaer, and Rensselaer’s HEOP program selects the students eligible for participation. The amount of assistance depends on need as determined by Rensselaer within state and federal guidelines. For more information contact the director, HEOP Program, Office of Minority Student Affairs, at (518) 276-6272.

**Other State Grant Programs**
Both Vermont and Rhode Island offer grant programs that provide partial support for study at Rensselaer.

Vermont Incentive Grant applications are made to the Vermont Student Assistance Corporation, Champlain Mill, PO Box 2000, Winooski, VT 05404-2000.

Rhode Island State Scholarship applications are made to the Office of Scholarships, Rhode Island Department of Education, 199 Promenade Street, Providence, RI 02908.

**Other Opportunities for Undergraduates**
In addition to the above, there are other possibilities for undergraduate students or, in some cases, their families.

**Part-time Employment** There are many opportunities for part-time work during the college year, both on the campus and in surrounding communities. It should be noted, however, that Rensselaer’s academic programs are demanding of both energy and time, and students should not expect to earn a large part of their college expenses through part-time employment. Information on part-time employment is available from the Career Development Center, (518) 276-6234.

**Alternative Loans** There are several alternative loan programs available for students attending Rensselaer. Additional information and/or application materials are available in the Financial Aid Office.

**Federal Parent Loan for Undergraduate Students (PLUS)** If creditworthy, parents of undergraduates may be eligible to borrow up to the cost of attending Rensselaer (minus other financial aid accepted). The PLUS interest rate varies annually with a cap of 9%, and repayment begins 60 days after the funds are fully...
disbursed. A one-page application form is available from the Financial Aid Office. The various lenders approve these loans based on a credit check, and loan proceeds are credited directly to the student’s account. The federal government deducts a 3% processing fee from the amount borrowed.

**Student Rights and Responsibilities**

As a student, you have the right to know and understand all aspects of the financial aid process at Rensselaer. Specifically, you have the right to ask the Financial Aid Office staff:

- What financial assistance is available, including information on all federal, state, and Rensselaer aid programs.
- What the deadlines are for submitting applications for each of the financial aid programs available.
- What our costs are, and what our policy is for making refunds to students who leave.
- What criteria we use to select students who receive financial aid.
- How we determine financial need, including how costs for tuition and fees, room and board, travel, books and supplies, and miscellaneous expenses are considered in the budget.
- What resources (such as parental contribution, other financial aid, assets, etc.) are considered in the calculation of need.
- How much of your financial need, as determined by the Institute, has been met.
- What the various programs included in your financial aid package mean.
- What portion of the financial aid you receive must be repaid and what portion is grant aid. If the aid is a loan, you have the right to know the interest rate, the total amount that must be repaid, the payback procedures, the total time you have to repay the loan, and when repayment is to begin.

If you feel you have been treated unfairly, you may request reconsideration of your award.

Along with these rights, students have responsibilities. Yours include:

- Review and consider all information about a school’s financial aid program before you enroll.
- Complete your application for aid accurately. Errors may delay your aid award. Intentional misreporting of information on application forms for federal financial aid is a violation of law and is subject to penalties under the U.S. Criminal Code.
- Return all additional documentation, verification, corrections, and/or new information requested by the Financial Aid Office or by other agencies to which you have submitted applications.
- Read and understand all forms you are asked to sign and keep copies of them.
- Accept responsibility for all agreements you sign.
- Notify a lender (someone who has made you a loan) of any change in name, address, or school status.
- Perform in a satisfactory manner the work that is agreed upon in accepting a Federal Work-Study award.
- Know and comply with all deadlines for application or reapplication for aid.
List of Undergraduate Scholarships
Industrial and foundation scholarships are financed by annual grants from their sponsors. Restricted endowed scholarships are awarded from annual endowment earnings; the date in parentheses indicates the year in which the scholarship was established.

Industrial and Foundation Scholarships and Annual Grants
Sal Alfiero '64 Scholarship First preference given to students from Buffalo, N.Y., or New Bedford, Mass.
Michael D. D'Angelo '94 Memorial Scholarship For a student enrolled in the school of engineering who graduated from East Greenbush School District or the Albany Academy for Boys or a high school in the N.Y. Capital District.
General Electric Foundation Scholarship For a minority student entering sophomore year. Student must be majoring in mechanical, electrical, or management engineering, or computer science and must rank in the top quartile of his or her class. Renewable for junior and senior years.
General Motors Minority Engineering Scholarship For a freshman enrolled in an engineering program of interest to General Motors. Renewable for sophomore, junior, and senior year.
IBM Minority Scholarship For students majoring in a field designated by IBM each year.
A. Lindsay and Olive B. O'Connor Foundation Scholarship Preferably for students from Delaware County, N.Y., or for students from counties surrounding Delaware County.
Herman J. Schafer Scholarship For electrical and civil engineering students.

Restricted Endowed Scholarships
Marion and Glen Abplanalp '36 X-Dimension Scholarship (1994) Preference to participants in Rensselaer Christian Association.
Roger Osborn Ackerman Scholarship (1989) Founded by bequest of Annie C. Ackerman as a memorial to her late husband. For a male engineering student.
George I. Alden Scholarship (1984)
Charles S. Aldrich Scholarship (1952) First preference given to a graduate of Vermont Academy at Saxtons River, Vt.
Kenneth G. Anderson '50 Scholarship (2000) First preference given to students enrolled in the Lally School of Management and Technology.
Rose O. and Arthur J. Anderson Memorial Scholarship (1984) For students from the New York state Capital District and the area of Concord, N.H., who have demonstrated leadership qualities and devotion to the Institute through participation in and contribution to its extracurricular activities.
Dr. Victor A. Babits Memorial Scholarship (1983) Established through gifts from family and friends in memory of Dr. Babits. For students majoring in electrical engineering who have completed their sophomore year.
William T. Bahr '49 Memorial Scholarship (2001) Established by Mary F. Bahr. For students enrolled in the School of Engineering with first preference for mechanical engineering majors.
Delwyn K. Barnes ’36 Scholarship (1991) Established by Delwyn K. Barnes ’36 and his grateful friends and colleagues in appreciation for his many years of active community service. Preferably for a student from Northbridge High School, Whittinsville, Mass.

Burt A. Baron ’59 Memorial Scholarship (2002) Established by Lynne L. and Victor B. Murray in memory of their close friend. First preference given to students enrolled in civil engineering.

Carolyn and Neal Barton ’58 Booster Scholarship (1989) For upper-class students who have encountered academic difficulty or because of extenuating financial limitations demonstrate a need for additional support to continue their studies.

Myrtle Isabel Bedell Scholarship (1985) Established by Captain Floyd C. Bedell in memory of his wife. For juniors and seniors majoring in civil engineering.

Dr. Arthur E. Bergles Scholarships (1996) For students in the Department of Mechanical, Aerospace, and Nuclear Engineering.

Alfonzo Bills Scholarship (1914) Founded by Mrs. Charles H. Knight of Troy. For a student from Troy High School.

Graham and Emmeline H. Blandy Scholarship (1916) Founded by Isaac C. Blandy, Class of 1887, in memory of his parents. For a student from Washington County, N.Y.

Charles H. Blitman Scholarship (1969) Founded by Mrs. Bernice M. Blitman in honor of her husband, of the Class of 1914.

Bornefeld Memorial Scholarship (1989) Established by Helen B. Bornefeld. For students enrolled in the School of Engineering, first preference for civil engineering majors.

BRAE Scholarship (2000) For students majoring in chemical engineering.

Christopher and Maria Brennan Scholarship (1941) Founded by Mary A. Brennan of Pittsfield, Mass., in honor of her father and mother. Preference given to students from western Massachusetts.


William and Gertrude Brotman Scholarship (1987) Founded by Stephen L. Brotman ’66 in honor of his parents. For students enrolled within the School of Science or Engineering.

William A. Browne Memorial Scholarship (2000) Founded by bequest of Florence T. Browne. For students enrolled in civil engineering.

Pauline Urban and Warren H. Bruggeman ’46 Scholarship (1989) For a student enrolled in the School of Engineering or Science, with first preference given to a student of Ukrainian heritage.


Harvey M. Bryans Scholarship (1974)

Julia Buchman Scholarship (1922) Founded by Edwin Buchman of Troy in honor of his mother. For a student from Lansingburgh (North Troy) High School.

Jane I. Burgess Memorial Scholarship (1983) Established by Richard M. Burgess ’27. For students who have completed the freshman year, preferably for civil engineering majors.

John F. Cahill Scholarship (1936) For a student from Troy.

Keith M. Callanan ’25 Memorial Scholarship (1982) Founded by a gift from Mrs. Gertrude DeYoung Callanan, widow of Keith Callanan. For students recruited as aspirants for varsity hockey.
Dale V. Carlson Scholarship (1980) Established through gifts from family and friends in memory of Dale V. Carlson. First preference given to two or more students from the same family attending RPI simultaneously. Second preference given to students from Minnesota.

Simon Peter Carman ’22 Memorial Scholarship (1999) For juniors or seniors majoring in civil engineering who rank in the top 10 percent (10%) of their class.

The Carr Scholarship for African American Students (2002)


Howard and Carol Cavanaugh Scholarship (1980) For students from the greater Buffalo, N.Y., area. Preference given to graduates of Canisius High School.

Leon C. Chamberlin ’28 Scholarship (1983) For undergraduate students in engineering. Selection based on academic excellence and financial need with preference for graduates of Salem Central School, Salem, N.Y.

Janice and Richard Chen ’71 Scholarship (1987) For a freshman international student from Hong Kong majoring in engineering or science.

Anthony A., Mary G., and Agnes B. Ciresi Scholarship (1981) Founded by Anthony D. Ciresi, Class of 1929, and his wife, Astrid B. Ciresi, as a memorial to honor Mr. Ciresi’s parents and sister. Preferably for a student from the state of Connecticut.


Class of ’31 Scholarship (1986)

Class of ’32 Scholarship (1983)

Class of ’37 Scholarship (1966) Preferably for sons and daughters of members of the Class.

Class of 1951 Transfer Student Scholarship (2000) For students transferring to Rensselaer in their junior year.

Class of ’71 Chinese Student Scholarship (1987) For a freshman international student from Hong Kong.

Arnold and Jessie Cogswell Another Chance Scholarship (1989) For students who have encountered academic difficulty and require additional support to continue their studies.

John D. and Mary J. Colby Scholarship (1977)

Ann M. and Frank J. Conte ’34 Scholarship (2000) Established by Frank J. Conte ’34. For students enrolled in the school of engineering.

Joseph Brandly Converse Scholarship (1964) Founded by Laura Keith Jones Converse in honor of her husband, of the Class of 1910. For a student in civil engineering, preferably from a southern state.

H. H. Cook Scholarship (1964) Founded by John Walter Gummo, Class of 1908. For a young man of American-born parents and a resident of Albany, N.Y.

Isabel L. and Dane H. Corey ’36 Scholarship (1990) For students enrolled in the School of Engineering or the School of Science, preferably residents of Vermont. Also, preference will be given to descendants of Isabel and Dane Corey.


Roman Cygan ’45 Scholarship (1994) First preference for students of Polish heritage from Easthampton, Mass., who have an interest in classical music.
Philomena C. and Walter C. Daniels ’50 Scholarship (2000) Established by Walter C. Daniels ’50. For students enrolled in the School of Architecture.

David M. Darrin ’40 Scholarship (1981) Originally established by David M. Darrin and later added to by his widow Margaret Darrin. For outstanding freshmen.


Delta Chapter Theta Chi Fraternity Scholarship (1996) For students who are members of Theta Chi Fraternity.


Rodney Derbyshire Scholarship (1981)

Derrick Family Scholarship (1999) Established by Margaret and George Derrick ’67. First preference given to students majoring in civil engineering.

E. Jane Devereaux Memorial Scholarship (1998) Established by Robert J. Devereaux ’53 in memory of his mother. Preference given to students from single parent background who are “average” students.

Ronald P. Diaz Scholarship (2001) First preference given to students enrolled in computer science.

David M. Diltz Scholarship (1981)

Joel Dolven Scholarship (1987) Established by family and friends in memory of Joel Dolven. For engineering students who are active participants in musical activities at Rensselaer.

John and Clara Doty Scholarship (1962) For a student in science or engineering.

Clarence W. Dunham ’20 Scholarship (1981) For students who have completed their freshman year and are majoring in civil engineering.


Ruth E. and Kenneth S. Eff ’33 Scholarship (1990)

Judith and Laurence Eiseman ’51 Scholarship (1992) For students enrolled in the School of Humanities and Social Sciences.

Beatrice W. Ellis Scholarship (1991) Established by William C. Ellis. For students majoring in science or engineering.

Catherine H. Ellis Memorial Scholarship (1990) Established by William C. Ellis. For students majoring in science or engineering.

Lila A. and Gerald S. Ellsworth ’50 Scholarship (2000) Established by Gerald S. Ellsworth ’50. First preference given to students enrolled in the Lally School of Management and Technology.


Rene F. Erkins Scholarships (1970) Established by Mrs. Eleanor Erkins in memory of her husband, for students in engineering.

Helaine Miriam Falkson Scholarship (1982) Established by Ralph E. Gorin in memory of his mother. For a student enrolled in an area of electrical engineering or computer science that, broadly construed, includes any of computer systems architecture, operating systems design, or the design of computer communications networks.

Alton Farrel Jr. Scholarship (1967) For a student from Connecticut, with preference given to residents of the city of Ansonia and vicinity.

The First Albany Scholarship (1993) Established by George McNamee and The First Albany Corporation. For students enrolled in the Lally School of Management and Technology, with first preference given to women and minorities.

Beatrice E. Fischbach Scholarship (1956) Founded by Jerome Fischbach, Class of 1938, in memory of his mother. For an upper-class student in architecture.


Mary and George Flitcher Scholarship (1999) Founded by a bequest from Helen M. Flitcher in honor and memory of her late husband’s parents.

Charles E. Frey ’59 Memorial Scholarship (1991) Established by Daniel O’Connell’s Sons, Inc., in conjunction with the O’Connell Companies and their subsidiary corporations. First preference given to a freshman majoring in civil engineering who is a child of an employee of Daniel O’Connell’s Sons, Inc.

Anna S. and Albert L. Gaetano Scholarship (1989) First preference given to a student who attended one of the following schools: Utica Senior Academy (Utica, N.Y.), The Gunnery (Washington, Conn.), or The Taft School (Watertown, Conn.).

Virginia and Ralph H. Gallinger ’30 Scholarship (1993) Established by Virginia Gallinger in memory of her husband, Ralph H. Gallinger ’30. For students majoring in civil engineering.

James W. Gaynor ’30/31 Memorial Scholarship (1991) Established by the family of James W. Gaynor. For students in Schools of Engineering and/or Science, with first preference given to female students.


Mary and Angelo Giardini ’32 Scholarship (1987)

Raymond A. Gibson ’23 Scholarship (1995) For students enrolled in the School of Engineering with first preference given to electrical engineering.


Elisabeth Smith Golden and Arthur Golden ’66 Scholarship (2002) First preference given to graduates of Westover School in Middlebury, Conn.

Philip Gowdey Scholarship (1998)

Richard Pope Graham ’42 Memorial Scholarship (1994) Preference for students enrolled in the Department of Mechanical, Aerospace, and Nuclear Engineering.
Wayne Green Scholarship (1985)


Kermit Gulden Memorial Scholarship (1997)

Thomas J. Guy Scholarship (1959) Founded by Thomas H. Guy in memory of his father. For a student from Troy High School or LaSalle Institute who is a resident of Troy.

Martin Hapeman ’58 Steinmetz Scholarship (1994) For students who are citizens of the United States and enrolled in the School of Engineering or the School of Science.

Oscar Hasbrouck Scholarship (1986) Founded by bequest of Catherine Hasbrouck Calhoun in memory of her father. For a student majoring in civil engineering.


Earl Hendry ’15 Memorial Scholarship (1996) Founded by bequest of Evelyn Hendry as a memorial to her husband.

Jacob E. Heyl Scholarships (1960)


Leon D. Holden Scholarship (1980) Founded by the will of Mr. Holden, a graduate of the Class of 1921.

Normond S. Holroyd ’29 Memorial Scholarship (1986) Founded by bequest of Isabell S. Gillett in memory of her first husband.


Jessie M. and Arthur J. Horan Scholarship (1977)


George T. Horton Scholarships (1963) Founded by a graduate in the Class of 1893. For students nominated by CBI Industries, Inc.

L. W. Houston ’13 Memorial Scholarship (1977) Established through gifts from friends in memory of Livingston W. Houston, a former president of Rensselaer. For a student in engineering.

Shih-Tze Hsiao ’76 Memorial Scholarship (1994) Established by the estate of Alice Wang, in memory of her son.

Helen and Robert Hughes Scholarship (2000) First preference given to students from the New Hartford and/or the East Ramapo Central School District in New York state.

Alan T. Hundert Memorial Scholarship (1978) Founded by Mr. and Mrs. Leo D. Hundert in memory of their son, a member of the Class of 1960. For a student in the School of Management.

Leonard W. Hyman Scholarship (1963) Founded by Lena Hyman in memory of her brother. For a student in chemistry who is a graduate of the public high schools in the city of Albany.


Harry C. and Dalys Oxnam Jaecker Jr. ’34 Scholarship in Management and Technology (1994) For students enrolled in the Lally School of Management and Technology.

Neil Howard Jagoda Scholarship (1981) Founded by his family and friends in his memory. Preference given to two or more students from the same family attending Rensselaer simultaneously.


Mary Low Kee Memorial Scholarship (1997) Established by Dr. Herbert Kee ’50 in memory of his grandmother. First preference given to Asian-American students.


Edward J. Kilcawley Memorial Scholarship (1994) For students majoring in environmental engineering.

Elwin F. Lackman ’41 Memorial Scholarship (2001) For students enrolled in the School of Engineering.

Joseph V. Landau Scholarship (1992) Established to honor Joseph V. Landau upon his retirement from active teaching at Rensselaer. For students enrolled in the premedical program in the School of Science.

Barbara and Stanley Landgraf ’46 Scholarship (1988) For students who are athletes on the varsity hockey team.

John and Marguerite La Pan Memorial Scholarship (1997) Founded by bequest of Marguerite La Pan. For a sophomore majoring in civil engineering.

Phyllis S. and C. Erik Larson ’55 Scholarship (1996)


Robert L. Levy ’62 Memorial Scholarship (1990) Established by Kenneth L. Foster. For students enrolled in the School of Engineering with first preference for students majoring in electrical engineering.

Alfred Li ’73 Scholarship (1993) For a freshman international student from Hong Kong.

Linear Technology Corporation-Glenn Mueller ’64 Memorial Scholarship (1994) For students in the Department of Electrical, Computer, and Systems Engineering interested in semiconductors and analog circuit designs.

Eric Lopez Scholarship (1992) Established by Nancy J. and Henry J. Lopez ’53. For students enrolled in the School of Engineering, with first preference given to Hispanic students.

Archibald Longworth Love III ’42 Scholarship (1993) For students enrolled in the School of Engineering with first preference to students pursuing study in the Department of Electrical, Computer, and Systems Engineering.
Wilfred T. Lowery Scholarship (1960) Founded by Miss Eva C. Lowery in memory of her brother, of the Class of 1916. For a student in electrical engineering.


Richard C. McCurdy Scholarship (1984)


James W. McEwan Memorial Scholarship (1973) Founded by Ethel J. McEwan in memory of her husband, James W. McEwan.

Hugh T. McKee ’30 Memorial Scholarship (1998) For students from Cohoes, N.Y.

Brian E. ’61 and Dorothy W. McManus Scholarship (1997) For a freshman with first preference given to a student from Texas.

Philip Henry Mead Memorial Scholarship (1993) For students enrolled in the School of Science or Engineering, with first preference given to U.S. students raised on a farm.


Arthur Hanfeld Miller Jr. Scholarship (1968) Founded by Mrs. Marie Alison Miller in memory of her son, of the Class of 1944. For a student in the School of Engineering.


Samuel J. Miller II Memorial Scholarship (1941) Founded by Mr. and Mrs. D. Henry Miller in memory of their son, of the Class of 1937. Preferably for a student from Connecticut in mechanical engineering.

W. Webb Moffett ’30 Scholarship (2000) First preference given to students who are members of Delta Tau Delta Fraternity.

Preston L. Moody Scholarship (1980) Founded by family and friends to honor Preston L. Moody, Class of 1922, on his 80th birthday. Preference given to graduates of public schools from the island of Oahu, Hawaii, majoring in civil engineering.

Thomas H. Moorehead ’56 Scholarship (1992) Established by Mrs. Patricia Moorehead in honor of her late husband, Thomas H. Moorehead ’56. For students enrolled in the School of Engineering, with preference toward mechanical engineering.

James F. Morrill ’52 Scholarship (1987) For students who are enrolled in the Schools of Engineering or Science, with first preference given to high school graduates in the St. Lawrence (N.Y.) County area.

John F. and Lewis R. C. Morse Scholarship (1977) Founded by Mrs. John F. Morse in memory of her husband, a former vice president of Rensselaer, and their son. Selection based on academic excellence, leadership, character, and financial need.

Mow Family Scholarship (1986) For a foreign-born student, preferably from Taiwan.

Glenn M. Mueller ’64 Memorial Scholarship (1994) Established by family and friends.
James C. Mullen '80 Scholarship (2000)

Edward Theobald Murphy Memorial Scholarship (1980) Founded by Helen S. Murphy in memory of her husband. Preference given to a male graduate of an Albany, N.Y., high school, majoring in civil engineering.

Reta G. Murphy Scholarship (1981) Founded by Arthur G. Murphy '32 in memory of his wife. For students recruited as aspirants for the varsity hockey team.

Edward F. Murray Scholarship (1929) Founded by Mrs. Edward F. Murray of Troy in memory of her husband. For a student from St. Joseph’s Parish in Troy or, in case there is no applicant from St. Joseph’s Parish, a Catholic student from Troy.


Theodore Newcomb Scholarship (1987) Founded by bequest of Theodore Newcomb. For students who are residents of the state of Connecticut.

Cynthia G. O'Hara '85 Memorial Scholarship (1998) Established by Cynthia’s family. First preference given to female students.

Ronald D. Pacchiana '54 Memorial Scholarship (1990) Established by the family, friends, and associates of Ronald D. Pacchiana '54. For students enrolled in the School of Engineering with first preference to those in civil engineering.


Neill S. Perri '93 Memorial Scholarship (1997) Established by Neill’s family. First preference for students enrolled in the Department of Mechanical, Aerospace, and Nuclear Engineering.

Henry F. Peters '49 Scholarship (1982) Established by Ruth Peters in memory of her husband. For students in materials engineering. Selection based on academic excellence and financial need with preference to applicants whose parent(s) are employed by Oregon Metallurgical Corporation.

Marvin L. Peterson '21 Scholarship (1983) Established in his memory by his wife and his children, Eleanor Splinter, Marilyn Kerwin, and Donald M. Peterson '55. For students in the Schools of Engineering or Science.

Simone C. Peterson '84 Scholarship (1999)

Joel H. Port '70 Scholarship (1974)

John Woodward Prosser Scholarship (1955) Founded by Mrs. Mary C. Prosser in memory of her son, of the Class of 1946. For an upper-class student.

Essie and Harriet Rader Scholarship (1979) Founded by Lawrence A. Rader, Class of 1958, in honor of his mother and his wife.


Rensselaer Endowed Scholarship (1960) Established through miscellaneous gifts given for scholarship assistance.

Rensselaer Faculty-Staff New Century Scholarship (1994) Established by members of the faculty and staff during the Campus Campaign.


Lynn S. Richards Scholarship (1957) Founded by Dr. and Mrs. Clifford S. Richards in memory of their son, of the Class of 1956. For a student enrolled in the School of Architecture.

William G. Riviello ’33 Scholarship (1997)

C. Sheldon Roberts Scholarship (1981) For graduates of secondary schools of the state of California, entering either the School of Engineering or School of Science.

Patricia W. Roberts Scholarship (1981) For graduates of secondary schools of the state of Oregon, entering either the School of Engineering or School of Science.

Edward I. Rudd, Jr. Scholarship (1997)

Gerald E. Sabian ’57 Memorial Scholarship (1991) Established by Ruth A. Sabian in loving memory of her husband. First preference given to students recruited as aspirants for the varsity hockey team who will major in chemical engineering or nuclear engineering.


Alan Keith Schaluck ’70 Memorial Scholarship (1995) Established by the estate of Annie B. Schaluck.

Harvey O. Schermerhorn Scholarship (1960) Preferably for a student of the Protestant faith from Albany or Troy.

Edward P. Schinman Scholarship (1945) Founded by the Bogue Electric Co. of Paterson, N.J., under the presidency of Edward Paul Schinman, Class of 1930. For a graduate of Wayne Township High School, Wayne, N.J., or if there is not an eligible candidate, for a graduate of one of the public high schools of Passaic County, N.J.

Claire and Roland Schmitt Scholarship (1988) For students who demonstrate leadership qualities.


Peter Bailey Seaman ’73 Memorial Scholarship (1999) Established by Jacqueline and Robert L. Seaman ’50 in memory of their son. For students enrolled in the Lally School of Management and Technology.

William F. Seber Scholarship (1972) For a graduate of Troy High School.

Irving Shapiro ’34 Scholarship (1974)

Professor Stephen R. Shatynski Memorial Scholarship (1983) Established by his family and friends. For students in the Schools of Engineering or Science. Preference given to two or more students from the same family attending RPI simultaneously.
Aaron Wiley Sherwood Memorial Scholarship (1971)
Edward B. Showell Scholarship (1973) Founded by Gertrude C. Showell, in memory of her husband, Edward B. Showell, Class of 1912.


Isabel and Frederick B. Silliman ’37 Scholarship (1988) Established by Isabel Silliman in honor of her husband. For students in the School of Engineering with preference for those in civil or electrical engineering.

Paula Loring Simon ’68 Scholarship (1994) For female students enrolled in the Information Technology Program and pursuing a secondary discipline in the School of Engineering.

Walter E. Smalley Scholarship (1979) For electrical engineering students from Dutchess County, N.Y.

Joel C. Spaeth ’59 Memorial Scholarship (1999) Established by Susan Spaeth in memory of her husband. For students enrolled in the School of Architecture.

Robert A. Spinnicchia ’77 Memorial Scholarship (1995) For students majoring in mechanical engineering.


William P. (Willie) Stanton Scholarship (1954) For an orphan, preferably from Rensselaer County, N.Y.


Carol and Joseph Stern ’61 Scholarship (1999) First preference given to students enrolled in the Department of Electrical, Computer, and Systems Engineering.

Anna C. and Frank J. Stevens Scholarship (1971)

George A. Strichman Scholarship (1985)

Robert O. Swanson ’58 Scholarship (2003) First preference given to top level candidates for admission who are underrepresented minorities, intending to major in engineering or science.

John and Eva Sweeney Memorial Scholarship (1976)


Texas Alumni Scholarship (1979) Established by alumni from Texas. For a student from Texas.

Martha and Clinton Thornton ’33 Scholarship (1989) For students in the School of Engineering.

The TISCO Scholarship (1988) For a student from Thailand or of Thai heritage.

Doris and Frank Tocher ’41 Scholarship (1993) First preference for a student in civil engineering.
Edward N. Toste ’79 Scholarship (1989) For members of Gamma Epsilon chapter of Tau Kappa Epsilon Fraternity who have exhibited leadership qualities. Recommendations by the board of trustees of the fraternity.

J. Philip Ulrich ’79 Scholarship (1989) For students in engineering and science with preference given as follows: 1) ex-Navy in nuclear engineering, 2) ex-military, 3) student holding a senior position of responsibility in student government or Union Club activity.

Angelo and Rosina DeStefano Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his parents. For students from Padula, Italy.

Anthony Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his brother. Preferably for students in nuclear engineering and science.

Laura Neske Valente Scholarship (1985) Founded by bequest of Professor Frank A. Valente in memory of his wife. Preferably for students in the physical sciences.


Madeline and Chester T. Vogel ’58 Scholarship (1990) in Memory of Bernard H. Vogel (1906-1999) For students enrolled in the school of engineering. First preference to students majoring in mechanical or electrical engineering for buildings, who demonstrate a commitment to becoming a professional engineer.

William J. Vonk ’49 / Karen Sievert Memorial Scholarship (1994) For an engineering student who is active in musical activities on campus.


Norman Wainer Memorial Scholarship (1964) Founded in memory of Norman Albert Wainer, Class of 1964. For an upper-class student, preferably in civil engineering.

Gladys Watson Scholarship (1981) Preferably for students from Newburgh Free Academy, Newburgh, N.Y.

Henry George Webb Sr. Scholarship (1967) Founded by Mrs. Henry George Webb Sr. in memory of her husband.

Jay J. Webb ’61 Family Scholarship (1990) Established by Mrs. Ruth Helen Wolf in honor of the Jay Webb Family. First preference to students, from the Chicago, Ill., or Newington, Conn., areas.

Todd M. Weber Memorial Scholarship (1979) Founded by Mr. and Mrs. Marvin Weber in memory of their son, of the Class of 1975. For students in geology.

Donald E. Weimer ’74 “2%” Scholarship (1996) For upper-class students enrolled in the School of Engineering or Science.


Caroline and Charles Williams Scholarship (1983) Established by Harry K. Williams ’22. Preferably for students who graduated from Sand Creek High School, Sand Creek, N.Y.

H. Arthur Williams Scholarship (1982)

Richard J. Williams ’23 Scholarship (2000) First preference given to students enrolled in the Department of Civil Engineering.
Helen G. Williamson Scholarships (1925) For students from Troy.
Mary K. and Elliot H. Woodhull ‘43 Scholarship (1992)
Harold F. Wrede Family Scholarship (1995) For students enrolled in the School of Engineering or Science.
Conrad Victor Yunker Scholarship (1937) Founded by Erma B. Yunker of Troy. For a student who has attended the public schools of Troy.

Graduate Financial Aid

Only full-time, degree-seeking graduate students are eligible for financial support from Rensselaer in the form of research assistantship, teaching assistantship, or fellowship. The Office of Graduate Education awards graduate Institute fellowships and the schools and departments award fellowships and research and teaching assistantships. In the awarding of aid, the Office of Graduate Education and the departments consider such factors as the candidate’s academic record and background, and, in some cases, financial need. Fellowships are awarded for the full academic year, and are typically allocated in March or April for the following academic year. All fellowships consist of a calendar year stipend of at least $16,000. Assistantships consist of a stipend of at least $12,000 for the academic year and $16,000 for the calendar year and financial support equal to the full tuition charge. The Financial Aid Office makes student loan determinations during July.

Academic departments review the progress of continuing graduate students each term. Continuation of or changes in aid are determined by this review and depend on satisfactory academic and research or teaching performance. A graduate student may be supported on a Rensselaer fellowship or assistantship for a maximum of five years, given continued availability of funds.

Financial Assistance from Rensselaer

Several types of assistance to help defray the cost of graduate study are available from Rensselaer funds.

Graduate Assistantships Each department selects a number of graduate students each academic year to work as graduate teaching and/or research assistants. The graduate teaching assistant assumes classroom, laboratory, and/or grading responsibilities for his or her department. The graduate research assistant conducts directed research with individual faculty members.

A full-time assistant receives both a stipend and tuition scholarship, and is responsible for no more than 20 hours of work each week. The remuneration and workload are determined by the department and approved by the Office of Graduate Education.

Opportunities exist for additional work and study during the summer in many programs.

Rensselaer Graduate Fellowships The Institute awards full-stipend, tuition, and fees fellowships for select incoming students. Nominees are put forward by the departments based on the strength of the application information. No separate forms are necessary.

Corporate, Foundation, and Private Fellowships Many corporations, foundations, and individuals offer fellowships for graduate study at Rensselaer. The benefits for grants vary; most include tuition allowances. Any student awarded a fellowship by the Institute will receive a minimum stipend of at least $16,000. A list of these fellowships is provided at the end of the graduate financial aid section of this catalog.
Federal Financial Assistance
The federal government offers the Stafford loan program to graduate students.

Federal Stafford Loan Program (Subsidized)
Graduate students may borrow up to $8,500 per academic year for a cumulative total of $65,500, including any loans for undergraduate study. Repayment begins six months after the student ceases to be enrolled at least half time. New borrowers have a variable interest rate capped at 8.25%. The federal government deducts a 3% processing fee from the amount borrowed.

Federal Stafford Loans (Unsubsidized)
Interest rate, loan limits, and processing fees are the same as for the subsidized Federal Stafford Loan, with interest payments beginning 60 days after the loan is disbursed. Interest payments can be paid monthly, quarterly, or can be capitalized and added to the loan principal.

Borrowers can receive both subsidized and unsubsidized loans for the same loan period. The combined total borrowed for both programs cannot exceed the maximum annual limit of $18,500 for graduate students. Stafford Loan eligibility is affected by changes in credit hours taken and in the amount of outside and department aid received.

New York State Aid
Residents of New York state may be eligible for Tuition Assistance Program (TAP) grants of $100 to $1,100. Awards are based on N.Y.S. taxable income. Applications must be filed annually with the New York State Higher Education Services Corp., 99 Washington Avenue, Albany, NY 12255.

Students who receive tuition awards from Rensselaer are required to apply for a Tuition Assistance Program award if eligible; the Rensselaer award will be reduced by the amount of the TAP award.

Other Opportunities for Graduate Students
Veterans’ Benefits Veterans and children of veterans may qualify for educational benefits. The veterans’ coordinator in the Registrar’s Office handles these benefits and should be contacted as soon as the student arrives on campus. The veterans’ coordinator will provide forms and information for initiating benefit procedures.

The Registrar’s Office is responsible for certifying all veterans who receive benefits. A veteran who changes his or her credit hour load or who withdraws from the Institute must notify the veterans’ coordinator immediately.

International Students Rensselaer encourages applications from highly qualified international students. Over 700 international graduate students representing more than 80 countries are currently enrolled at Rensselaer.

Financial aid is available to well-qualified first year students in the form of fellowships and assistantships. Competition for awards is very high; approximately 30% of accepted students are offered aid. Generally, awards are committed well before the start of the academic year; awards are usually mailed during March and April for the following fall term.

The minimum provision for living and personal expenses for the 2002-03 academic year is approximately $11,900 beyond tuition and fees. If the student intends to stay in the United States for the summer vacation period and enroll in classes at Rensselaer during that time, he or she must have adequate additional funds. Students also must pay for round-trip transportation to Rensselaer. A nonrefundable fee of $35 is required for an orientation program held prior to registration. Immigration restrictions generally preclude spouse employment.
List of Graduate Fellowships

The following fellowships are administered by departments, and in some cases the Office of Graduate Education, and are awarded after a review of the admissions application. No separate application is necessary.

AT&T Graduate Scholarship Programs for doctoral study in science and engineering.

Air Products & Chemicals Grant-in-Aid for graduate study in chemical engineering.

Philip L. Alger Fellowship for graduate study in engineering ethics.

American Cyanamid Fellowship for disadvantaged students.

American Nuclear Insurers Fellowship for graduate study in nuclear engineering.

American Nuclear Society Scholarships for graduate and undergraduate studies in nuclear engineering.

BASF Corporation Grant-in-aid for graduate study in chemical engineering.

Michael W. Bellanti Fellowship for graduate study in nuclear engineering.

Irene and Robert P. Bozzone '55 Fellows in Management and Technology for graduate students enrolled in the management and technology MBA program.

Robert S. Brown '52 Fellows Program for travel fellowships for architecture students.

Karin and Ellis Chingos '37 Fellowship

Bill Clemow '71 Memorial Fellowship for graduate study in electrical, computer, and systems engineering.

Cluett Peabody Fellowship for disadvantaged students.

Dr. Andrew N. Dascheff '89 Memorial Fellowship for graduate study in chemistry.

Civil Engineering Fellowship Sponsored by Alumni in Construction

Department of Energy (DOE) Fellowships for graduate studies in nuclear engineering.

DeWitt-Wallace Foundation Fellowship for graduate study primarily in humanities and social sciences.

Joaquin B. Diaz Memorial Fellowship for graduate study in mathematical sciences.

Dow Chemical Grant-in-aid for graduate study in chemical engineering.

DuPont Grant-in-aid for graduate study in chemical engineering.

DuPont Grant-in-aid for graduate study in mechanical engineering.

Eastman Kodak Fellowship for graduate study in electrical, computer, and systems engineering.

Eastman Kodak Grant-in-aid for graduate study in chemical engineering.

Electric Power Engineering Fellowship for graduate study in electric power engineering.

Equitable Fellowship for graduate study.

Exxon Education Foundation Stewardship for graduate study in civil engineering.

Exxon Grant-in-aid for graduate study in chemical engineering.

Exxon Grant-in-aid for graduate study in electrical, computer, and systems engineering.

Nancy Fitzroy Scholarship for graduate study for women in engineering.

FMC Corporation Grant-in-aid for graduate study in chemical engineering.

W. Cary Franklin Fellowship for graduate study in mechanical engineering or an allied field.

General Electric Foundation Fellowship for graduate study in electrical, computer, and systems engineering and in materials engineering.

General Electric Traineeships for disadvantaged students.

Goldbaum Family Fellowship for graduate studies in nuclear engineering.
W. R. Grace Fellowship for graduate study in chemical engineering.
E.T.B. Gross Endowment Fund for graduate study in electric power engineering.
Grumman Scholarship master’s award for graduate study.
GTE Foundation Fellowship for graduate study in electrical, computer, and systems engineering, and computer science.
Gulf Oil Fellowship for disadvantaged students.
David Hansen Fellowship for graduate study in chemical and environmental engineering.
Robert G. Hawkins Fellowship for underrepresented students in graduate management studies.
Herman Family Fellowship for women in entrepreneurship.
Fannie and John Hertz Scholarship for graduate study in engineering or science.
Charles S. Humphrey Fellowship for graduate study for a Canadian citizen in science or engineering.
IBM Fellowships for graduate study in computer science.
IBM Fellowships for graduate study in integrated circuits.
IBM Fellowships for graduate study in materials engineering.
IBM Fellowships for graduate study in mathematics.
IBM Mass Spectrometer’s Ion Physics Lab Fellowship for graduate study in nuclear engineering.
Intermagnetics General Corporation Fellowship for graduate study in condensed matter physics.
Interscience Incorporated Fellowship for graduate study in condensed matter physics.
Howard P. Isermann ’42 Fellowships for graduate study in chemical engineering.
Professor Howard Kaufman ’62 Memorial Fellowship for graduate students in electrical, computer, and systems engineering, with preference given to students working in the area of control systems.
Carolyn and William A. Klein ’62 Fellowship for graduate study in entrepreneurship.
Stanley I. Landgraf ’46 Memorial Fellowship for graduate students with preference given to former recipients of the Barbara and Stanley Landgraf ’46 Scholarship.
Y. L. Liu Fellowship for graduates of Hong Kong universities.
George Mahe ’42 Fellowship in memory of John L. Sharp ’42.
Harry F. Meiners ’52 Fellowship for graduate study in physics.
Merck Fellowships for graduate study in chemical engineering.
Mobil Chemical Grant-in-aid for graduate study in chemical engineering.
National Academy for Nuclear Training (NANT) Fellowships for graduate study in nuclear engineering.
Dr. Ernest F. Nippes ’38 Graduate Research Enhancement Award for graduate students in materials engineering.
North American Philips Fellowship for graduate study in condensed matter physics.
North American Philips Graduate Fellowship for graduate study in electrical, computer, and systems engineering.
Parthesius Fellowship for graduate study.
Perkin Elmer Fellowship for graduate work in electrical, computer, and systems engineering.
Michael Aloysius Philbin Memorial Fellowship for graduate study in civil engineering.
Procter & Gamble Grant-in-aid for graduate study in chemical engineering.
Raytheon Co. Fellowship for disadvantaged students.
Reinert-Rader Fellowship in Financial Technology for graduate students in the Lally School of Management and Technology.
Richards Scholarship for graduate study in civil engineering.
Robert S. Roller Fellowship in Lighting for graduate students exploring fundamental issues in lighting technologies at the Lighting Research Center.

Veera and Arjun Saxena Fellowship in Microelectronics for outstanding Ph.D. students working in the area of microelectronics.

Schenectady Chemicals Industrial Fellowship for graduate study in chemical engineering.

Shavell-Weinman Graduate Research Enhancement Award for graduate study in economics or humanities related to understanding economic behavior.

Slezak Memorial Fellowship for graduate study in chemistry.

Chauncey and Doris Starr Graduate Fellowship for worthy and needy students with first preference to those pursuing doctoral study in the interdisciplinary area of energy and the environment.

Donald Sturges Memorial Fellowship for disadvantaged students in engineering and management.

Takats Fellowship for graduate study for Western New York residents in mechanical, civil, nuclear, or biomedical engineering.

Union Carbide Grant-in-aid for graduate study in chemical engineering.

Voorhees Fellowships for graduate study in management.

Joanne Wagner Memorial Fellowship for graduate study for women in communications and rhetoric.

Yamada Corporation Fellowship for graduate study for Japanese citizens.

Stephen B. Zimmerman '66 Memorial Fellowship for study in industrial and management engineering.
Tuition and Fees

Bills covering the fees of any term are mailed before the start of the term and are payable no later than the date specified, approximately one month before classes start. A student’s registration is not complete until he or she has paid or arranged for payment of all fees. Academic credit, degrees, grade reports, diplomas, and transcripts are not granted to students who have not fulfilled all financial obligations to the Institute. If special arrangements for payment are necessary, they should be made through the Bursar’s Office.

It is the students’ and parents’ joint responsibility to ensure that timely and accurate applications are made for financial aid, scholarships, and loans. In the event Rensselaer Polytechnic Institute grants credit for these or any other payment source, and payment is not received from that source, the Institute will expect payment from the student and/or parent. Should a student or parent fail to pay any amounts due Rensselaer Polytechnic Institute in accordance with the terms of this catalog, the Institute may at its option increase the amounts due by any attorneys’ fees, collection agency fees, or any other costs or charges incurred in the collection of any amount not paid when due.

No fees or payments will be refunded other than tuition and room and board charges as outlined below. Rensselaer subscribes to the Policy Guidelines for Refund of Student Charges as issued by the Office on Self-Regulation Initiatives Program of the American Council on Education.

Questions regarding assessment of fees, purpose, and payment should be directed to the Bursar’s Office.

The schedule below is effective as of the summer session of 2003.

Monthly Installment Plan As an alternative to paying relatively large amounts twice a year, Rensselaer offers a monthly payment plan. The plan permits academic year charges for tuition, fees, residence, and board to be paid in 10 equal installments. There is a $60.00 per year service charge for use of the Monthly Installment Plan.

Applications to participate in the plan and additional information regarding the plan are normally mailed to prospective and returning students in mid-April. Applications may also be obtained at the Bursar and the Financial Aid Offices. There is no interest charge associated with the plan.

Late Payment and Unpaid Balances Any balances not paid or covered by financial aid by the due date noted on the bill will be subject to a late payment fee of $175. In addition to the $175 fee, students with unpaid balances after the first day of classes will be unable to receive grades or transcripts, register for future terms, or receive diplomas. If any amounts are still outstanding at the end of the term, Rensselaer will require a one-semester leave of absence. Readmittance after this leave is contingent upon payment of money owed and proof of financial capability for the next term.

Tuition

Undergraduate Tuition The tuition for a normal undergraduate program (12 to 21 credit hours a semester) is $27,700 per academic year. This includes use of apparatus, athletic fields, and gymnasium, but charges for breakage in laboratory classes are additional.

Summer session tuition for undergraduates is $865 per credit hour.

Undergraduate students who are allowed to take more than 21 credit hours in any term, exclusive of ROTC, will be charged an additional $865 for each credit hour in excess of 21. Overload charges will be based on the student’s registration at the end of the eighth week of classes. No appeals due to late drops will be accepted.
Undergraduate students who are allowed to take fewer than 12 credits are charged $865 per credit hour unless they are certified as full-time for TAP purposes. Charges for students who drop to fewer than 12 credit hours after the fifth week of classes will not be adjusted below the full-time charge.

**Graduate Tuition** Full-time graduate tuition is $27,700 per academic year. Payment of this tuition allows a student to register for 12 to 15 credit hours in each of the fall and spring semesters. A student paying tuition and taking between 12 and 15 credits in the fall and spring is considered a full-time student throughout that calendar year. Students must register for at least 12 credits per semester to maintain full-time status. The only exception to this requirement is for those students serving as teaching assistants. These students may register for a minimum of 9 credits to maintain their full-time status. Students enrolling for more than 15 credits during the fall or spring terms will be charged the academic year tuition rate plus a per-credit-hour rate of $1,155 for each credit hour exceeding 15 credits or for each credit taken in the summer sessions.

Part-time graduate tuition is paid on a per-credit-hour basis of $1,320 per credit hour.

**Registration in Absentia** Students who are primarily engaged in pursuing their degrees, have completed their course work, and are physically located off campus and not using institutional resources (e.g., labs, library, student services, etc.) can register as "Registration in Absentia" for a maximum period of one year. The fee for so doing will be $500 per semester/or summer term. Students registering in absentia are considered full-time students.

**Cooperative Education** Graduate students engaged in cooperative education (Co-op) are considered full-time students. No tuition is assessed for Co-op students unless the student elects to take classes. Co-op students taking classes are charged the per-credit-hour rate associated with full-time students ($1,155 per credit hour for 2003/2004).

**Tuition Refunds for Official Withdrawals** Except for the application fee and admissions deposit (entering students only), all payments will be refunded if a student officially withdraws before Final Registration. Students who withdraw or who are dismissed from Rensselaer before the completion of a term will be charged tuition according to the portion of the term spent in residence. Before any refunds are made for whatever reason, official written notification of withdrawal and requests for refunds must be submitted to the dean of students or to the Office of Graduate Education as applicable. The refund schedule after Final Registration for Fall and Spring terms is:

- Less than 1 week: 100%
- Less than 2 weeks: 90%
- Less than 3 weeks: 80%
- Less than 4 weeks: 70%
- Less than 6 weeks: 60%
- Less than 7 weeks: 50%
- Less than 9 weeks: 40%
- More than 9 weeks: 0%

**Graduate Tuition Refunds for Part-Time Graduate Students Fall and Spring Terms:**

- Less than 5 weeks: $100%
- More than 5 weeks: 0%

**Veteran's Benefits** Any veteran who changes his or her credit hour load or withdraws from the Institute must notify the veteran's coordinator in the Registrar's Office immediately.
Fees

Residences The range of campus housing costs is given below. Detailed information regarding facilities, assignments, specific costs, refund policies, and services is available from the Office of Residence Life.

Single Student Housing ...............................................................................................$3,866 to $6,102
Family Housing ....................................................................................................$514 to $755 monthly

Students who accept a campus housing assignment are expected to occupy their rooms for the full academic year. Residence charges are refundable for students who withdraw or are dismissed, according to the same schedule as tuition refunds.

Contract Dining The costs for the meal plans are listed below. Dining charges are refundable on a pro-rated basis for students who withdraw or are academically dismissed. If the student should withdraw prior to late registration, the entire amount of the charges will be refunded.

Platinum Plan ..............................................................................................................................$4,178
(unlimited meals plus $100 MAD* per semester)**
Diamond Plan ..............................................................................................................................$3,982
(unlimited meals plus $75 MAD* per semester)
Gold Plan .....................................................................................................................................$3,992
(unlimited meals from 10 a.m.-7:30 p.m. plus $50 MAD per semester)*
Emerald Plan ................................................................................................................................$3,866
(unlimited meals from 7:30 a.m.-9:30 a.m. and 4:00 p.m. -7:30 p.m. plus $60 MAD per semester)*
Silver Plan ....................................................................................................................................$3,734
(unlimited meals Monday-Friday from 7:30 a.m.-7:30 p.m. plus $50 MAD* per semester)
Bronze Plan ..................................................................................................................................$2,876
(unlimited meals from 7:30 a.m.-2:30 p.m. plus $200 MAD* per semester)

Activity Fee An activity fee is assessed by the Rensselaer Union and carries with it Union membership privileges. The fee is required of all students except full-time university employees who are registered for graduate study and Professional and Distance Education studies students. The fee is nonrefundable except where withdrawal is made prior to late registration and notification is made in the same manner as required for tuition refunds.

Undergraduate students ...............................................................................................$222.75 per term
Graduate students ........................................................................................................$115.50 per term
Summer students .........................................................................................................$108.00 Session I
$54.00 Session II
$54.00 Session III

**Includes late night dining on Monday-Thursday from 10:30 p.m. to 11:30 p.m. at Russell Sage Dining Hall.

* MAD-Meal Plan Advantage Dollars

Co-op students pay the fees listed if their assignments are within 25 miles of the Rensselaer campus.

Health Center Fee All matriculated regular undergraduate and graduate students taking courses at Rensselaer are charged a Health Service Fee of $178.00 per six-month period. Students paying the fall semester fee may access the Student Health Center from August 15 to February 15. Students paying the
spring semester fee may access health services from February 15 (or, for students admitted or readmitted in the spring term, the first day of spring classes) to August 15. Students admitted or readmitted to summer sessions pay a pro rata fee of $61.50 per session.

This is a mandatory fee that registered students may not waive unless they are more than 25 miles from campus while on a co-op assignment.Granting of Health Center Fee waivers is at the discretion of the medical director. This fee provides access to the Student Health Center.

**Health Insurance Premium** All matriculated regular undergraduate and graduate students are charged $351 each semester for the Rensselaer Student Accident and Sickness Insurance Plan. Like the Health Center Fee, coverage extends for six months (August 15 to February 15, February 15 to August 15). Details on this plan are mailed to all students prior to enrollment and are also available at the Health Center. The insurance plan may be waived if you have equivalent insurance coverage. Waiver of this plan is required each year and must be requested no later than September 15 (February 15 for students admitted or readmitted in the spring term). Details on waiver applications are included with your tuition bill. Enrollment/Waiver forms are also available at the Student Health Center. Approval of waivers is at the discretion of the medical director. Students who waive the health insurance plan still have access to the Student Health Service. Students are urged not to waive this inexpensive and important coverage.

Optional dependent insurance coverage is also available. Enrollment forms are available at the Student Health Center.

An option to add an additional coverage upgrade layer that will increase the lifetime maximum payable for all conditions combined to $250,000 is available. Contact the Student Health Center for further information.

**Dental Insurance Premium** All matriculated regular graduate students are charged $74.94 each semester for the Guardian Dental Insurance Plan. Waiver of this fee is allowed by showing proof of comparable dental insurance coverage and by completing a dental fee waiver form available at the Health Center. Deadline for waiver of this fee is September 15 for the fall and February 15 for the spring semester.

**Graduate Thesis Fee** This fee is payable as soon as the thesis is accepted, as follows:

- Master's candidates: $10 for binding one copy of the thesis.
- Doctoral candidates: $80, which covers binding two copies of the thesis for use of the Folsom Library, as well as microfilming and publication of the thesis text and an abstract.

**Late Payment Fee** A fee of $175 is charged to students who have not paid their accounts in full on or before the specified date. A request for waiver can be made by obtaining forms at the Bursar's Office. Additional appeal may be made through the student judiciary process if the bursar denies the initial request for waiver.

**Orientation Fee** All entering first year and transfer students, will be charged for the opportunity to attend programs held during the summer or before fall or spring semester for overall orientation, academic advisement, and course registration. This year’s fees are $150 for first year students, $100 for transfer students, and $50 for spring admissions. This fee is nonrefundable except where withdrawal is made prior to the fall Final Registration date for fall admissions or prior to spring Final Registration for spring admissions.

**Orientation Fee for International Graduate Students** All entering foreign graduate students will be charged $35 for the opportunity to attend a special program held before fall and spring semesters. Attendance is mandatory; students entering for the summer session will participate in the fall program. The fee covers arrival assistance, off-campus housing search service, general orientation, and social activities (services and programs are more limited in the spring semester). This is a nonrefundable fee. Any
questions or concerns should be directed to the Office of International Services for Students and Scholars.

**Late Registration Fees** A $50 fee is levied on students who were enrolled the previous semester and register after the registration period specified in the academic calendar. An additional fee of $25 is charged students in the above category who register after the first day of class as specified in the academic calendar. These fees are imposed to cover the added cost of late registration processing. After payment of these fees, a request for reimbursement can be made by application at the Registrar’s Office.

**Returned Payment Fee** A $25 fee is charged for checks, MasterCard, or Visa transactions returned by the bank. In addition, if term clearance was granted based on the returned item, the late payment fee will also be charged and the student’s term clearance may be suspended until the returned item is made good.

**Validation Examination Fee** The fee for an examination to establish credit for work done elsewhere than in an accredited institution is $75 for each examination.

**Transcript Fee** A transcript fee of $25 is charged all students upon entry to Rensselaer.

**Motor Vehicle Fees and Fines** Parking at Rensselaer is very limited and student vehicles are restricted by permit to specific areas. An annual vehicle registration fee is charged all students who park a motor vehicle (including motorcycles and mopeds) on Rensselaer property. Parking permits are available from the parking office located in the Visitors Information Center. Parking and driving requirements are available on-line at [http://www.rpi.edu/dept/parking](http://www.rpi.edu/dept/parking). Violations of the requirements involve tickets, fines, fees, booting (wheel lock), and loss of parking privileges. Fees and fines are billed to student accounts. Credit card transactions are not accepted in the parking office. An added fee is charged for bank checks returned by the bank.
Each student is expected to be familiar with the academic regulations of the university and the particular requirements for his or her educational program. The student has sole responsibility for complying with regulations and meeting degree requirements as set forth in this catalog and as amended from time to time.

General academic standards and regulations are set forth below, followed by the university requirements for degrees. Students should also consult the current edition of *The Rensselaer Handbook of Student Rights and Responsibilities*, which explains disciplinary regulations and related matters. This handbook is available from the Office of the Dean of Students.

Exceptions may be granted to the undergraduate academic regulations when circumstances suggest this to be in the best interest of the student's educational objectives. Such requests are handled individually, and students should first consult with their faculty advisers about the correct procedure. The Advising & Learning Assistance Center approves exceptions for undergraduates. In only the most compelling circumstances will exceptions be made to the graduate academic regulations. After consulting with their academic adviser, graduate students can seek exceptions at the Office of Graduate Education.

**Registration**

Before the end of each semester, all students enroll for courses for the next semester. With the help of a program adviser or by using a plan of study, specific required and elective courses are selected, and this information is submitted to the registrar. Registration procedures are in the *Class Hour Schedule*, which is available from the Registrar's Office.

Courses with insufficient registration will be canceled. Students affected will be notified so that they can select another course. The university reserves the right to cancel or not offer any course listed in the *Rensselaer Catalog*.

**School Ombudspersons**

**Architecture**
Frances Bronet, Greene 210B
276-6866, fax 276-3034, e-mail: bronef@rpi.edu
or Mark Mistur, Greene 302, 276-6868, e-mail: mistum@rpi.edu

**Engineering**
Robert W. Messler, JEC 3018
276-6620, fax 276-4860, e-mail: messlr@rpi.edu

**Humanities and Social Sciences**
Elizabeth Large, Sage 5208
276-2576, fax 276-4871, e-mail: largee@rpi.edu
Times for Registration
All full-time continuing students must register during the period specified each semester by the registrar. New, part-time, or readmitted students must register before the first day of classes. An undergraduate may not register for a semester after the tenth class day of the term. Graduate students may not register after the tenth class day of the term.

Waivers to the above deadlines are not normally given unless circumstances beyond the student’s control prohibit complying with the deadlines. Undergraduates wishing to register after the deadline must have a signed waiver from the director of the Advising and Learning Assistance Center. Graduate students may be granted a waiver from the Office of Graduate Education. Students granted a waiver must pay late fines and file specified forms with the registrar. Students will not be permitted to register after the start of the fifth week of classes except in extraordinary circumstances.

An off-campus student may register for Independent Study, Thesis, or Research by writing to the department chair or adviser prior to the end of the Add Period. The chair or adviser will arrange for the registrar to register the student.

A student’s registration is not complete until he or she has paid or arranged for payment of university fees. If special arrangements for payment are necessary, they should be made through the Bursar’s Office. Every full-time student entering Rensselaer must submit a medical history and record of physical examination on a form provided by Rensselaer. A student’s registration is not complete until this form is submitted.

Late Registration Fees
Full-time continuing students who miss registration must pay $50 and register before the first day of classes each term. All students who fail to register before the start of classes will be charged $25 to cover additional processing costs. For full-time continuing students, this charge is added to the $50 fee. Students must pay late registration fees prior to registering.

Students who wish to petition for a refund of the fee must fill out a Late Registration Fee Waiver Request after registering in the Registrar’s Office. The registrar evaluates the waiver request, and the student is informed of the decision. Students who wish to appeal this decision must write to the registrar and ask for a review of the decision. Late Registration fees will not be waived unless the student was unable to register or notify the registrar during the required period because of a personal emergency beyond the student’s control.

Cross-Registration at Consortium Colleges
It is possible to register for courses, at no additional tuition charge, at 20 other colleges and universities in the Capital Region, all members of the Hudson Mohawk Association of Colleges and Universities:
In addition to Rensselaer, consortium members include:

Adirondack Community College
Albany College of Pharmacy
Albany Law School
Albany Medical College
The College of Saint Rose
Empire State College
Courses taken at one of the consortium colleges are entered on the student’s record in the same manner as courses taken at Rensselaer and thus carry term and cumulative hours and quality points. No more than half of a student’s academic credits may be taken at a consortium college in any semester. Students cannot cross register for courses offered at Rensselaer.

For graduate students, prior to enrolling in a course taught at a consortium college, the course should appear on an approved Plan of Study. The Office of Graduate Education reserves the right not to accept the course toward a degree program if it was not listed on an approved Plan of Study.

Cost for courses taken at one of these colleges is covered by the tuition charge at Rensselaer and subject to the same regulations that apply for courses taken at Rensselaer. Such courses may be taken on the Pass/No Credit option and may be added or dropped in accordance with the policy in effect at Rensselaer. The Pass/No Credit option is not available to graduate students. When the other college is on a calendar year that differs from Rensselaer’s, time adjustments for adding or dropping courses or placing courses on Pass/No Credit will have to be made. The student taking such courses is responsible for learning the last date for such changes. This information may be obtained from the registrar.

The general regulations governing the interchange of students and other forms and information concerning the program are available at the Registrar’s Office.

**Williams and Harvey Mudd Exchanges**

The Williams and Harvey Mudd Exchanges, available only to undergraduates, will be entered on the student’s record in the same manner as those taken at Rensselaer or at a consortium college. These courses, therefore, carry term and cumulative hours and grade points. Those students who successfully apply to the dean of undergraduate education for either exchange program will spend an entire semester on the Williams or Harvey Mudd campus.

**Auditing**

Auditing is attending a course without credit. Participation in recitations or discussions (or the requirement of such participation) is at the discretion of the instructor. Auditors must register after classes begin, but before the end of the second week of classes, and may not register for credit in the audited course later in the term. They may, however, register in a later term for this course on a credit hour basis. A permanent record will be maintained for the audit. The only grade given for the audited course is “AU” (Audit). Full-time matriculating Rensselaer students can audit up to three courses per semester on a nonfee basis with the permission of their adviser and the course instructor. Rensselaer students must be full-time for the summer term in order to be eligible to audit on a nonfee basis. The spouse of a full-time teaching assistant, research assistant, or fellowship recipient may audit one course per semester at no cost. All other persons, if granted auditing privileges, will be charged the regular credit hour fees for the course.
Program Adjustments (Drop/Add)

All Students Specific regulations are given below for undergraduate and graduate students. The following apply to all students.

Dropping or adding courses is done via Rensselaer’s Web registration system. Detailed instructions are available in the Class Hour Schedule.

Responsibility for dropping or adding courses prior to the deadline rests entirely with the student. Failure to fulfill the responsibility because of an oversight, ignorance, or possibility of low grades is not sufficient grounds to petition for permission to drop or add a course after the deadline. It is the policy of the Institute that no petitions be accepted for the retroactive dropping or adding of a course except under extenuating circumstances beyond the student’s control.

No credit will be given for a course in which the student is not properly registered. Failure to attend a class for which a student is registered or unofficial notification to the instructor does not constitute dropping a course and will result in an Administrative “F” (“FA” grade).

Undergraduate Students The following additional regulations apply to program adjustments:

■ Undergraduates may add a course any time during the first ten class days of a semester.
■ A student may change sections of a course any time during the first two weeks of the semester.
■ A student may drop a course any time during the first eight weeks of the semester.
■ If a full-time undergraduate student is taking less than 12 credit hours, the director of the Advising and Learning Assistance Center must approve.
■ During the summer sessions, courses may be added during the first week of each session. Courses may be dropped any time before the end of the third week of classes.

Only the Academic Standing Committee via the director of the Advising and Learning Assistance Center can make exceptions to the drop/add rules. Students wishing exceptions must petition with supporting documents from parties involved, such as instructors, adviser, or medical director.

Students who have approval to drop a course after the eighth week of classes will receive a grade of “W” in the course.

Under no circumstances will a student be permitted to register after the start of the last week of classes for the term.

Full tuition is charged after the fifth week of classes and prorated for courses dropped prior to the fifth week of the semester for students withdrawing from the university.

Graduate Students The following additional regulations apply to program adjustments:

■ Tuition charges for part-time students are based on the number of credits a student is enrolled in at the end of the fifth week of the term independent of any further late drops. Any additions made after the fifth week result in additional tuition charges. Tuition for part-time students is charged on a per-credit-hour basis.
■ When program adjustments are made, the student’s Plan of Study should be updated accordingly.
■ During the summer sessions, courses may be added during the first week of each session. Courses may be dropped any time before the end of the third week of classes.
■ Graduate students may add a course any time during the first ten class days of a semester.
■ A student may change sections of a course any time during the first two weeks of a semester.
■ A student may drop a course during the first eight weeks of the semester.
■ A graduate student must take at least 12 credit hours each term to be considered a full-time student.
unless employed as a teaching assistant, in which case a minimum of 9 credits is allowed. Full-time graduate students must maintain full-time status at all times throughout their graduate career.

Only the Office of Graduate Education can make exceptions to the drop/add rules. Students wishing exceptions must petition with supporting documents from parties involved, such as instructors, adviser, or medical director.

Students who have the approval of the Office of Graduate Education to drop a course after the eighth week of classes will be given a grade of “W” in the course.

**Academic Load**

**Undergraduate** The normal academic load for undergraduates is 14 to 18 credit hours. An undergraduate whose program exceeds 21 credit hours must secure the written permission of his or her adviser. An undergraduate whose program is less than 12 credit hours must secure the written permission of his or her adviser and the director of the Advising and Learning Assistance Center.

The minimum requirement for a full-time undergraduate is 12 credit hours. An undergraduate student whose program is reduced to fewer than 12 credit hours in any semester may continue at Rensselaer only on the recommendation of the Committee on Academic Standing. The student must petition the committee for such recommendation.

**Graduate** The full-time load for a graduate student normally is 12 to 15 credit hours each term. A student who wishes to register for more than 15 credit hours must have the permission of his or her department and the approval of the Office of Graduate Education. A full-time student may register for as many as 12 credit hours during the summer, at the rate of six credit hours for each of two summer terms, with the permission of the adviser and the chairperson of the department. Summer tuition is charged at $1,155 per credit hour for full-time students.

**Graduate Teaching Assistants** Graduate teaching assistants are not required to take more than 9 credits per semester. However, at their own discretion and with Department Chairperson and Office of Graduate Education approval, graduate assistants may take up to 15 credits per semester for the following reasons:

- 3 additional credits assigned to a research project for thesis.
- 3 additional course credits added to meet a specific academic objective.

**Rensselaer Staff** The maximum study load for a full-time member of the Rensselaer staff is eight credit hours per term. This includes all courses taken for credit, whether undergraduate or graduate. Requests from staff members to register for graduate research beyond the maximum study load are decided by the student’s department and the Office of Graduate Education.

**Advisers**

A faculty adviser is assigned to each student to assist in academic program planning toward a sound plan of study. Accordingly, the adviser’s signature is usually required on Pass/No Credit forms, thesis registration forms, and related forms. Students should contact their advisers on any matters pertaining to their educational programs. The Advising and Learning Assistance Center, the academic department, and the Office of Graduate Education are also available for consultation.
Undergraduate Curricula and Courses of Instruction

To ensure that all plans of study are educationally coherent and satisfy degree requirements, a curriculum has been constructed for each field in which the baccalaureate degree is offered. These curricula consist of required courses, recommended courses, course options, and electives. These curricula are outlined in the section of this catalog describing individual schools and departments.

Course Listing

Course descriptions can be seen in the Course Description section. Courses offered for undergraduate academic credit are those at the 1000-4000 levels. Higher-level numbers indicate courses designed primarily for graduate students.

Substitutions for Required Courses

Substitutions for required courses are permitted only with the approval of the heads of the departments concerned and the dean of the school or a designated representative. Where substitutions are granted, written notice must be filed with the registrar.

Undergraduates Taking Graduate Courses

Undergraduates may not ordinarily take graduate courses, unless they have already been accepted for graduate study by either the Professional School or the Office of Graduate Education. Exceptions will be considered on an individual basis. An undergraduate wishing to take a graduate course must submit to the Office of Graduate Education a Request to Take a Graduate Course form (available online and at the Office of Graduate Education) that has been signed by his/her adviser and the instructor in charge of the course. Normally the Office of Graduate Education will not approve such a request unless the student meets the requirements for graduate admission. Generally this means that the student should be a senior with a grade point average of at least 3.0. The Office of Graduate Education reserves the right to cancel the registration of an undergraduate in a graduate course if the student has not received approval to take the course. A student with senior status and a grade point average of 3.0 does not need permission from the Office of Graduate Education to take a graduate-level course. No tuition refund will be given. Courses taken at the 6000 level must be taken on a letter grade basis; they may not be taken under the Pass/No Credit option.

Undergraduates admitted to the Professional Program of the School of Engineering may have to take certain graduate courses and may elect other such courses with the adviser’s approval.

Curriculum Changes

Because life and growth are synonymous with change, the university continuously reevaluates its educational programs and procedures. This means that no curriculum is static, and the listings in this catalog are subject to modification. The entering student, therefore, is advised to keep abreast of his or her curriculum requirements.

An undergraduate student regularly admitted to the university is entitled to transfer from one curriculum to another, subject to the adequacy of related course work and availability of space. In certain curricula, such as the accelerated biomedical program and the management-law program, transfer possibilities are limited.

To make such a change, the student must complete a Change of Curriculum form available from the Registrar’s Office. Those students on academic probation or needing more advice will be referred to the department chair to which the transfer is requested.
Bachelor's Degree

The bachelor’s degree is awarded to students who have pursued successfully, as evaluated by the faculty, a plan of study that encompasses several disciplines. Each plan of study has at least two objectives: first, to reach a preprofessional standing or fundamental mastery in a selected discipline; second, to develop some grounding in knowledge found in liberally educated persons, an appreciation of technology and science, and an openness to ongoing learning.

The requirements of each baccalaureate program are outlined as follows:

- The number of courses and credit hours is prescribed by each curriculum. Minimum requirements are 124 credit hours for science and for humanities and social sciences majors, 124 for management, 128 for engineering and for the Bachelor of Science (Building Sciences) degree in the School of Architecture, and 168 for the professional degree in the School of Architecture.
- The minimum grade point average (GPA) is 1.80.
- To receive a baccalaureate degree, a student must have been admitted to the curriculum corresponding to the degree, must have satisfied the curriculum requirements, and must be enrolled in that curriculum at the time the degree is granted.
- The course content in physical, life, and engineering sciences must total a minimum of 24 credit hours, including at least eight credit hours of mathematics. For information on additional requirements see the School of Science section of this catalog.
- The course content in humanities and social sciences must total a minimum of 24 credit hours, including at least eight credit hours in the humanities and eight credit hours in the social sciences. For information on additional requirements see the School of Humanities and Social Sciences section of this catalog.
- Every student is required to successfully complete a writing course or a writing intensive course for a grade. Students can also satisfy this requirement with an AP English score of at least four, an SAT verbal score of at least 670, or a transfer course meeting Institute requirements for a writing intensive course. Students with an SAT score less than 610 are strongly advised to satisfy this requirement by taking a writing course.
- The minimum course concentration in the area of the selected discipline is prescribed by each curriculum but cannot be less than 30 credit hours.
- At least 24 credit hours are to be elective, of which no less than 12 credit hours are unrestricted electives.
- The student must be registered full-time for a minimum of four semesters. Two semesters of part-time study at Rensselaer will be considered equivalent to one semester of full-time study. In addition, the student must complete a minimum of 48 credit hours at Rensselaer, all of which will be applied to the baccalaureate degree. If a transfer student elects to study abroad or enroll in the co-op program, no more than 12 such credits may apply to the 48 needed for the bachelor’s degree. The student’s plan of study at Rensselaer must include at least 16 credits of courses above the 1000 level in the major field, or in an approved concentration.
- The Institute requires a degree candidate to earn the last 30 credits in courses completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting toward the student’s last 30 credits and require approval of the director of the Advising and Learning Assistance Center.

Baccalaureate candidates must have passed all of the prescribed academic work and have satisfied the fee requirements. Candidates must also be in good academic and disciplinary standing. Undergraduate students on probation at the time of completion of course work may be required to meet certain stipulations for removal from probation. However, such requirements may be waived for those students whose cumulative GPAs satisfy the baccalaureate degree requirements. In general, a term’s work with grades of not
less than C will be required in programs arranged by the Committee on Academic Standing. The director of the Advising and Learning Assistance Center will state requirements to the students in writing.

Degree candidates must be registered during the semester in which they intend to graduate and must file a degree application with the registrar by the dates specified in the academic calendar. Students who previously applied for graduation but did not complete all their requirements on time must submit a new application specifying the new date of graduation.

Double Degrees
A student may become a candidate for a second baccalaureate degree when he or she has completed: (1) the equivalent of at least two terms (30 credit hours) of additional work beyond the requirements of a single degree, and (2) the courses in the department in which the student is registered and such other courses as are required for the second degree.

Dual Majors
Undergraduate students who fulfill all the degree requirements for two curricula and who have met the conditions below will have completed a dual major. They will receive one diploma noting both majors. (1) The student must designate a first-named and second-named major in writing at least one semester prior to graduation, and have the appropriate department(s) approve this designation prior to filing the dual major form with the registrar. (2) Each student will be assigned an adviser in each department who will monitor progress towards degrees in that department. (3) The degree clearance officer in the department will certify that the student has met the degree requirements in that department. (4) The 24 credit hour mathematics/science requirement and the 24 credit hour humanities and social sciences requirement will satisfy the Institute requirements for both majors.

Minors
Within the distributional requirements described, the student may elect any courses that meet his or her personal or professional needs. Courses can be chosen to form a minor—that is, a set of courses coherent based on subject, methodology, or other factors. Many departments offer one or more such minors; several of the minors are interdisciplinary. A student wishing to complete a minor should consult with the adviser for that minor before completing the second course in it (departmental secretaries have this information). Minors vary in their requirements from 15 to 21 credit hours. Courses for the minor may not be taken on a Pass/No Credit basis.

Graduate Curricula and Courses of Instruction
Individual curricula are given under the heading of departments in which they are offered. Course requirements and credit hours usually are tabulated term by term, with specific courses listed by number and title.

Curriculum Changes
Because life and growth are synonymous with change, the university continuously reevaluates its educational programs and procedures. This means that no curriculum is static, and the listings in this catalog are subject to modification. The entering student, therefore, is advised to keep abreast of his or her curricular requirements. Announcements of changes, if any, are available from the departmental offices.
A graduate student who wishes to change from one curriculum or department to another must file a Graduate Change of Status form, available at the Registrar’s Office. This change requires approval of the chairpersons involved and of the Office of Graduate Education. When further information is needed before a change can be approved, the student may be requested to follow graduate admission application procedures.

Courses and Grade Requirements
Courses offered for graduate credit bear the suffix numbers 4000-9990. However, those designated by 4000-4990 are open for credit to both graduates and advanced undergraduates, and there are limitations on the number of such courses that may be applied to a graduate degree. Undergraduate courses below the 4000 level may not be used for credit toward graduate degrees. Also, graduate students are not permitted to take courses on a Pass/No Credit basis.

The minimum average of all grades used for credit toward an advanced degree must be B. If a student’s grades fall below a B average, the Office of Graduate Education may request that the department conduct a formal review to determine whether continuation is warranted. The student’s adviser, committee, or department may recommend to the Office of Graduate Education that the student whose performance is unsatisfactory be dropped from the graduate program. A student who has accumulated two failing grades will be dropped from the graduate program.

Satisfactory Performance
Continuation in the graduate program requires satisfactory performance on the part of the student. Satisfactory performance is not limited to the academic record, but includes other appraisals of the student’s record and ability.

Substitutions for Required Courses
Substitutions for required courses are permitted only with the approval of the heads of the departments concerned and the Office of Graduate Education. Where substitutions are granted, written notice must be filed with the registrar.

Plan of Study
The graduate program is flexible and affords each student an opportunity to plan a course of study suited to his or her own objectives. To assure a coherent program in accord with the student’s maturing capacities and aims, each student is to maintain, with the adviser’s assistance, a Plan of Study for the degree for which he or she is studying.

The Plan of Study should be submitted during the student’s second full-time semester. To be considered valid, the Plan of Study requires the approval of the adviser and the designated departmental person. The Plan of Study is to be prepared on the forms provided by the Office of Graduate Education. Upon approval by the adviser and the designated departmental person, the department will transmit the original to the registrar, with copies going to the Office of Graduate Education, the student, and the adviser. The student should also keep a copy for himself or herself.

Each student who has filed a Plan of Study should register in the usual manner and in accordance with the plan. If there are any significant changes, a revised Plan of Study must be submitted promptly following the same procedure outlined above.

Master’s Degree
A student is admitted to study for the master’s degree when the student’s record indicates ability to do advanced work in that field. When a student decides to do graduate work in a field different from the
undergraduate degree, however, the department may require him or her to establish additional background by taking certain undergraduate courses.

The Master of Science degree is under the auspices of the Office of Graduate Education. The Professional School in the School of Engineering provides the Master of Engineering degree. The professional Master of Architecture degree is provided by of the School of Architecture and the Master of Business Administration degree is provided by the Lally School of Management and Technology. The School of Humanities and Social Sciences provides the Master of Fine Arts.

**Office of Graduate Education Requirements**

A candidate for a master’s degree must:

- Complete a Plan of Study, approved by the department with satisfactory grades. The master’s requires 30 credit hours beyond the bachelor’s degree. Certain programs have been specifically approved for additional credit hours, (e.g., the MBA and MFA require 60 credit hours). At least half the total credit hours presented toward the degree must have the suffix numbers 6000-6990, with the further limitation that no more than 15 credits of 4000-4990 courses are to be allowed.
- Satisfy residence requirements.
- Present an independently written (single author) thesis or project, if required.
- Pursue a Plan of Study that will lead to the completion of all requirements, including those of the department, within two and one-half years.
- Pay binding fee, if applicable.
- File a degree application with the Registrar’s Office by the date specified in the academic calendar for the semester in which he or she plans to be graduated. If a degree application was filed for a previous semester but the requirements were not fulfilled, a new degree application must be filed for the semester in which the student actually is graduated.

Degree candidates who at any point in their tenure at Rensselaer are, or become, full-time students must maintain continuous full-time registration throughout their Rensselaer academic career to be eligible to graduate. These students must be registered full-time during the semester in which they intend to graduate, and:

- Be in good academic and disciplinary standing.
- Satisfy the culminating experience requirement as specified by the department.

A student pursuing more than one master’s degree at Rensselaer must meet the above requirements for each degree sought.

**Residence and Time Limit**

A student working for a master’s degree is required to be registered for at least two terms and to complete a minimum of 24 credit hours of resident instruction for each master’s degree sought. Department residency must be met in addition to the Office of Graduate Education requirements. Residency requirements for the Troy campus may also be met within programs offered at certain off-campus sites (branch campuses).

For full-time students, all work for a master’s degree, whether done at Rensselaer or elsewhere, must be completed within two and one-half years of registration for the first credits applied toward the master’s degree. Full-time students not fulfilling the master’s degree requirements by the end of two and one-half years will be dismissed unless the Office of Graduate Education has given advanced approval for additional time to complete the degree. Extensions are granted for only the most compelling reasons and are rare. If approved, the student must register full-time for any additional terms and tuition is charged at the normal full-time rate. The student must be in good academic standing and have an acceptable Plan of Study. Satisfactory performance is not limited to academic record, but includes other appraisal of the student’s record and ability.
The Office of Graduate Education may initiate a departmental review of any student who has accumulated 36 or more credits on a master’s degree program (66 or more for the Master of Business Administration) without satisfying degree requirements unless the individual’s Plan of Study has been approved for more than 36 (66) credits. The review will consider whether the student should be dropped from the graduate program.

**Thesis, Projects, and Professional Projects**

Certain departments may specify presentation of a thesis or completion of a master’s project as a requirement for a master’s degree. Usually six, and no more than nine, credit hours are allowed for a master’s thesis or multiple semester master’s project. Professional projects are completed in one semester and are limited to four credit hours for each project.

In a department that ordinarily requires a thesis or project, a student may be permitted to substitute additional courses that constitute a comparable culminating experience on recommendation of the adviser and with the approval of the department chair.

The thesis or project report must be presented to the candidate’s adviser for review at least two weeks before the end of the term in which the degree is to be awarded. Any final examination on the thesis or project is to be held by the date listed in the academic calendar for the year. Theses and certain multiple semester projects are graded either S (satisfactory) or U (failed). Professional projects and certain other multiple semester projects receive a standard letter grade.

The candidate must deposit a copy of the thesis (or certain multiple-semester projects), together with the adviser’s written approval of both content and format, at the Office of Graduate Education at least one week before the end of classes in the term in which the degree is to be awarded. The Office of Graduate Education must certify that the approved document has been deposited before the degree is awarded. Only work meeting the highest standards of integrity will be accepted for degree requirements at Rensselaer. Academic integrity is a requirement of continued good academic standing and for the awarding of a graduate degree.

**Doctoral Degree**

Rensselaer awards the doctor’s degree in recognition of high achievement in scholarship and independent investigation. The Doctor of Philosophy degree, under the auspices of the Office of Graduate Education, is awarded when the dissertation is directed toward making an original contribution to fundamental knowledge in a particular field or in an interdisciplinary field. A dissertation that is scholarly, creative, original, and publishable may deal also with the relation of a discipline to educational problems and objectives within the field. The Doctor of Engineering degree, under the auspices of the Professional School of the School of Engineering, is awarded when the student proposes an engineering problem of substance and develops a solution to it in a creative and distinguished manner.

**Office of Graduate Education Requirements**

A candidate for the doctor’s degree must:

- complete a Plan of Study with satisfactory grades containing 90 credit hours beyond the bachelor’s degree including any appropriate work completed toward a master’s degree. In satisfying this requirement at least two-thirds of the total credit hours, excluding thesis, must contain the suffix numbers 6000-6999, with the further limitation that no more than 21 credit hours of 4000-4990 courses are to be allowed.
- Satisfy residence requirements.
- Form an approved doctoral committee.
- Pass a candidacy examination.
Present an independently written (single author) dissertation.

■ Pass a final examination.

■ Pursue a Plan of Study that will lead to the completion of all requirements, including those of his or her department, within seven years.

■ Satisfy the binding fee requirement.

■ File a degree application with the Registrar’s Office by the date specified in the academic calendar for the semester in which he or she plans to be graduated. If a degree application was filed for a previous semester but the requirements were not fulfilled, a new degree application must be filed for the semester in which the student actually is graduated.

■ Be in good academic and disciplinary standing.

To be eligible to graduate, degree candidates must have either: maintained continuous full-time registration; maintained continuous full-time registration following a change of status from part-time to full-time; or been, at all times, a part-time student. Under no circumstances will a full-time student be allowed to transfer to part-time status and maintain eligibility for graduation.

Full-time degree candidates must be registered full-time during the semester in which they intend to graduate.

Residence and Time Limit

A student working for the doctor’s degree is required to take at least 45 credit hours of course and/or thesis work at the Troy campus. Residency requirements for the Troy campus may also be met within programs at certain off-campus sites (branch campuses).

For full-time students, all work for the doctorate must be completed within seven years of registration for the first credits applied toward the 90 credits required for the Ph.D. All doctoral candidates must pass the appropriate examinations as determined by their department within two years of registration for the first credits applied toward the Ph.D. Full-time students entering with a master’s degree in their field of study must finish all degree requirements for the Ph.D within a continuous five-year time period. Students who have not met their applicable time limit will be dismissed from the program unless the Office of Graduate Education has given advanced approval for additional time to complete the degree. Extensions are granted for only the most compelling reasons and are extremely rare.

Individuals who leave Rensselaer without obtaining an authorized leave of absence and who have not requested an extension before the seven-year limit will be dismissed from the program. Individuals who do receive authorized leaves because of serious illness, involuntary military service, or maternity leave can, with the submission of the medical or military documentation, request the Office of Graduate Education to exclude up to two years of authorized leave time from the seven-year limit.

Doctoral Committee

The chair of the student’s department assigns a temporary adviser to guide the student until a doctoral committee can be appointed. As soon as the student has chosen a dissertation area, he or she must arrange to conduct the dissertation work with a dissertation adviser who is a full-time tenure-track member of the faculty. The dissertation adviser then consults with the chair of the student’s department regarding the nomination of a doctoral committee of at least four members. The department chair sends the nominations to the Office of Graduate Education, which approves the doctoral committee.

The committee must include at least four full-time tenure-track Rensselaer faculty members. Exceptions to this rule must be approved by both the department chair and the Dean of Graduate Education. One committee member must be outside the student’s department; the outside member may also be an additional fifth member, from outside the university if approved by the department chair. The committee members represent the principal areas included in the student’s Plan of Study. They assume responsibility for this plan and also for the student’s candidacy and final examinations.
Plan of Doctoral Study
A prospective candidate for the doctorate ordinarily follows a Plan of Study of a minimum of 90 credit hours beyond the bachelor's degree, including any appropriate work completed toward a master's degree.

Candidacy
A student may apply for the candidacy examination, given by the doctoral committee, when:
■ His or her course work nears completion.
■ He or she has the approval of the doctoral committee.
This examination determines if the student has made satisfactory progress. Certain departments require their graduate students to pass preliminary examinations before the candidacy examination is taken.

A student is admitted to candidacy for the doctorate when he or she has passed the candidacy examination and received formal approval for such candidacy from his or her doctoral committee and department. When these requirements are met, the chair of the doctoral committee should notify the Office of Graduate Education of the student's candidacy. All degree requirements must be completed within three years of admission to candidacy.

Dissertation and Final Examination
The doctoral dissertation demonstrates the candidate's capacity for independent work. It embodies the results of an original investigation in the candidate's principal field of study on a subject approved by the student's doctoral committee. Only work meeting the highest standards of integrity will be accepted for degree requirements at Rensselaer. Academic integrity is a requirement of continued good academic standing and for the awarding of a graduate degree. The field of the dissertation should be chosen as soon as possible after entry upon doctoral study. A manual, Thesis Writing, containing required format specifications, is available from the department, the Office of Graduate Education, or on the Web on the Office of Graduate Education's home page at http://www.rpi.edu/dept/grad/gradschool.html.

The dissertation is presented to the candidate's dissertation adviser at least one month before the end of the term in which it is expected that the degree will be awarded. Each member of the doctoral committee must be presented with an unbound copy of the dissertation at least one week before the final examination is scheduled.

Dissertation Defense/Final Examination When the dissertation is completed, the candidate must defend it in a public examination conducted by his or her doctoral committee, which passes on its acceptability. The final examination is to be held by the date listed in the academic calendar for the year. The committee transmits a record of its decision on the dissertation examination to the Office of Graduate Education.

Dissertation Submission After passing the final examination and no later than two weeks before the end of the term in which the degree is expected to be awarded, the candidate must deposit at the Office of Graduate Education two original copies of the dissertation in its final form including the required format specifications. A copy of the abstract, no longer than 350 words or 2,450 characters, with an abstract title page also must be included. The dissertation should be placed in a manila envelope with a copy of the title page on the front side. The original copy of the abstract with an abstract title page also must be included. The abstract title page should be the same as the dissertation title page except for the words "An Abstract of a Dissertation" etc. added. The title page for the dissertation must have the original signatures of the members of the doctoral committee. A Thesis/Project Examination Form, approving both content and format, signed by the chair of the doctoral committee must accompany these. The Office of Graduate Education must certify that the approved dissertation has been deposited before the degree can be awarded.

Publication of Dissertation Before the candidate is certified for graduation, he or she must pay a dis-
sertation fee to cover the costs of microfilming, publication of the abstract, and binding two original copies for preservation and use in the general library. A copy of the microfilm is deposited in the Library of Congress, and the abstract is published in the monthly journal, Dissertation Abstracts. Copies of the dissertation on microfilm and the journal then are available from University Microfilms, Ann Arbor, Michigan. The forms to be filled out for this purpose are available in the Office of Graduate Education and may be completed either prior to or at the time the dissertation is submitted.

A student who wishes to publish or present publicly any portion of his or her dissertation before it has been accepted in fulfillment of his or her degree requirement must have the permission of the adviser or chair of his or her doctoral committee. Any dissertation material so presented must include the following statement: “This paper is taken in part from a dissertation to be submitted in partial fulfillment for the degree of _______________________ in the Department of _______________________ at Rensselaer Polytechnic Institute.”

The right of conventional publication is in no way abridged by microfilming, and the student is urged to seek additional publication in technical journals or elsewhere.

## Academic Credit

### Units of Credit

Academic credit is assigned in terms of credit hours. For formal course work, one credit hour represents one lecture or recitation hour or one laboratory period per week for one term. Approximately three hours of endeavor per week, both in and out of class, are associated with each credit hour. Contact hours are the number of class hours per week. When the number of contact hours differs from the credit hours for a course, the course description so indicates.

### Students Entering Rensselaer as Freshmen

Incoming freshmen may be eligible for advanced placement or advanced standing.

**Advanced Placement** The student should request the Educational Testing Service (ETS) to send Advanced Placement (AP) scores to the Registrar’s Office at Rensselaer. The scores are evaluated and notice of the decision is sent to the student. Credit is granted, but there is no grade assigned and the credit is not included in calculating the grade point average (GPA).

**Advanced Standing** Credit may be granted for college-level work taken while in high school. Transfer credit will not be given for any college courses taken while in high school if these courses are used in obtaining the high school diploma. One exception is the matriculated student who attends college full time and transfers back credits to complete the high school diploma. This rule does not exclude the possibility of placement in a higher level of a subject area without being given academic credit for the placement. “Placement” in this case does not refer to the Educational Testing Service Advanced Placement Tests, which are accepted at the Institute depending on the level of score.

After admission, the student should have an official copy of a transcript from the college sent to the Registrar’s Office at Rensselaer along with a copy of the course description for each course. The appropriate academic department evaluates the material. If acceptable, it is posted on the student’s record and a copy of that record is sent to the student. No grade is given and it is not included in calculating the GPA.

Rensselaer Polytechnic Institute does not accept the College Level Entrance Program (CLEP) for credit.

### Undergraduate Students Entering Rensselaer from Another College

Students entering Rensselaer from another college must apply to the Office of Transfer Admissions. The Office of Transfer Admissions notifies the student of the results of preliminary evaluation and requests the student to send a final tran-
script at the end of the current semester to the Office of Transfer Admissions. After the final course evaluation is made, the credit hours will be posted on the student’s permanent record. No grade is given for accepted courses, nor are these courses included in calculating the GPA.

**Undergraduate Transfer Credit**

Subject to specific approval, academic credit for courses taken at another college or university may be transferred to Rensselaer. For information on additional requirements for transferring Humanities and Social Sciences credits or Science credits, refer to the individual school’s section of this catalog. Rensselaer students taking courses at other institutions should follow the following procedures.

The Transfer Credit Approval form, which can be obtained in the Registrar’s Office, should be used for approval of all transfer credit granted. Equivalent “A,” “B,” or “C” grade work is required for transfer credit. Students desiring to take course work at other institutions should obtain approval prior to enrollment at that institution. Transfer credit cannot be guaranteed unless prior approval is obtained, since unapproved courses may not be equivalent to Rensselaer courses. In addition, many institutions require proof of prior approval before allowing a visiting student to register.

Students desiring transfer credit must have the registrar of the other institution forward an official transcript and course descriptions (or the student may submit copies of catalog course descriptions) to the Rensselaer Registrar’s Office. When the Transfer Credit Approval form, the official transcript, and course descriptions are received, the Registrar’s Office will forward the material to the appropriate departments for their review (if approval was not previously obtained). Final grades will be checked for courses previously approved, and if at least a “C,” credit can be given directly. A student who repeats at another college a course failed at Rensselaer may be required by the department at Rensselaer to pass an examination.

The institute requires a degree candidate’s last 30 credits in courses to be completed on this campus or through a program formally recognized by the Institute. Transfer courses are limited to two courses or eight credits counting toward the student’s last 30 credits and require approval of the director of the Advising and Learning Assistance Center.

A student transferring back to Rensselaer who now holds an associate’s degree and who formerly was a Rensselaer matriculating student may begin a new cumulative GPA subject to the approval of the director of the Advising and Learning Assistance Center. His or her former Rensselaer courses will still appear on the permanent record but will not be calculated in the new GPA.

**Credit by Validation Exam**

Academic credit for college-level proficiency may, in special cases, be established for formal study done in other than an accredited institution by validation exam. Only full-time students are eligible. A written statement submitted to the registrar detailing the basis of their experience is required. A student must obtain approval from the registrar and the adviser or department head in the area concerned. Validation examinations are not permitted for courses previously failed or audited. A fee is charged for each examination taken. Students should check with the Registrar’s Office for procedures and appropriate forms.

**Graduate Credit by Transfer and Examination**

Credit for graduate work completed at other accredited institutions may be offered in partial fulfillment of the requirements for a degree at Rensselaer when the work is appropriate to the student’s program. As a rule, this work will have been earned prior to admission at Rensselaer. Students already enrolled at Rensselaer who wish to take courses elsewhere must obtain the prior approval of his or her adviser and the Dean of Graduate Education.
Because the residence requirement for the doctor’s degree is 45 credit hours beyond the master’s degree, not more than 45 credit hours may be transferred toward the doctorate.

Double counting credits for multiple degrees is subject to approval by all departments.

Application for the transfer of credit must be made to the student’s department. The department is responsible for evaluating course work taken elsewhere and reporting allowable transfer credit to the registrar on the transfer credit approval form. Courses taken elsewhere and approved for transfer to Rensselaer must be taken at the graduate level and have a grade of “B” or better to be approved. They are not considered in computing the B average requirement.

A student who obtains the approval of his or her adviser and the Dean of Graduate Education to work elsewhere while already enrolled at Rensselaer must apply for transfer of credits as soon as the credit has been earned. Transfer of Credit forms may be obtained from the Registrar’s Office.

Academic credit for college-level proficiency may, in special cases, be established for formal study done in other than an accredited institution by validation exam. A student must obtain approval from the registrar and the adviser or department head in the area concerned. A fee is charged for each examination taken. Students should check with the Registrar’s Office for procedures and appropriate forms. Normally a validation exam is used to satisfy a specific course requirement, thereby allowing the student to replace the required course with an appropriate elective on his or her Plan of Study. Credits earned by validation exam may not be used to satisfy residence requirements.

A graduate student who has taken courses at Rensselaer as a special nondegree student may transfer to a degree program a maximum of 12 credits earned in that status. If a student has taken a graduate credit course while an undergraduate, received a grade of B or better, and did not use the credit to fulfill the requirements for the bachelor’s degree, he or she may request, through the faculty adviser, that the Office of Graduate Education count the credit toward the requirements for an advanced degree.

Class Attendance and Examinations
Attendance Requirements
The academic department concerned generally determines requirements for class attendance. Each instructor must make these requirements clear at the beginning of the course, and the student has to abide by them. If the instructor does not inform the class of the attendance policy, the class should ask for a statement of the policy.

The instructor maintains the academic standards held to by Rensselaer. The instructor who defers a class or changes his or her class schedule for any reason is still responsible for arranging for the work that is missed. The entire class must agree with any change in a class meeting schedule or final exam schedule.

When an instructor finds a student’s attendance unsatisfactory, the student may be referred to the dean of students for counseling.

A student who is a member of an authorized team or organization for which events are scheduled is excused from class attendance during the time actually spent away from the campus or during the hours of the events on campus. The student still has to complete the work that is missed. A student admitted to Samaritan Hospital will, upon request, receive a written excuse from the medical director.

Because Rensselaer is a nondenominational university that welcomes all faiths, the decision regarding absence from classes and laboratories on religious holidays is left to the individual. In the case of conflicts between the university calendar and an individual’s beliefs, students, faculty, and administrative staff will make arrangements to assure that religious participation is not restricted.
Final Examinations

The examinations given at the end of each semester take place at the times announced on the examination schedule, published prior to the examination period. No student is allowed more than one final examination in a course. (See Senior ‘F’ Examination Rule.)

Every student has to take all of his or her examinations at the scheduled time unless excused because of illness or other sufficient reason by the dean of students or, in the case of graduate students, by the Office of Graduate Education. Procedures for resolution of conflicts (i.e., examinations scheduled for the same time), will be announced with the final examination schedule. The reason for an expected absence should be presented in advance of the examination. The dean of students or the dean of the Office of Graduate Education will accept no excuse on the grounds of illness unless the medical director approves it.

The student who has been excused by the dean of students or dean of the Office of Graduate Education from a final examination is reported “NE” (Not Examined) and will be examined later at a time set by the instructor. Only the dean of students and the Office of Graduate Education may excuse a student from a final examination. Unless so excused, a student who is absent from final examinations is given zero credit for the exam and may at the discretion of the instructor be given an “F” for the course.

Senior “F” Examination Rule

Senior students who have no outstanding failures on record that would prevent graduation and who fail only one course taken during the first semester of their senior year and who are candidates for a degree at the end of the second semester, may be eligible to take a re-examination in the course that was failed. These students must not have outstanding “I” or “NE” grades, either in prior semesters or in the current semester that would prohibit them from graduating. A senior who fails a course in the second semester may take a re-examination providing the course failed is the only course preventing his or her graduation.

Students must apply to the registrar to qualify for a Senior “F” Exam. The registrar will certify the eligibility of the student for a re-examination and authorize the instructor to examine eligible students.

For students who seek to qualify for their bachelor’s degree in the spring semester, the following applies: A student failing a course in the fall semester of the senior year will be examined after the middle and before the end of the spring term. If it is possible to repeat the failed course in the spring semester, the student has that option. A re-examination in a failed spring semester course may not be taken until the first summer session at the earliest. The time of the re-examination will be at the discretion of the department involved.

Students should know that it may not be possible to give re-examination in courses that require certain physical facilities until those facilities are again available.

For students who seek to qualify for their bachelor’s degree in August or December, similar rules apply. The student should consult the registrar for details.

Under no circumstances will an examination be taken later than one year after the end of the term in which the failure occurred. The results of the re-examination when passed or failed will not alter the term or cumulative grade point average previously earned nor remove the “F” grade from the record. When passed, a statement is posted on the transcript stating the failed course was passed by re-examination.

Study-Review Period

No classes or exams will be held during the study-review period at the end of the semester. This day or these days will be the study period for final examinations.
Grading System

Letter Grades

The letter grades and their meanings are:

A = Excellent
B = Good
C = Average
D = Passed (not available to graduate students)
F = Failed
FA = Failed (due to administrative reasons)
I = Incomplete course work
IP = In Progress (multiple-term course)
NE = Not Examined
NC = Failed a Pass/No Credit course (undergraduates only)
P = Passed a Pass/No Credit course (undergraduates only)
S = Satisfactory in a Satisfactory/Unsatisfactory graded course
U = Unsatisfactory in a Satisfactory/Unsatisfactory graded course
W = Withdrawn
WI = Failed (course that was previously graded “I” and the student did not meet the deadline for completing course work)
Z = Grade Unknown—see instructor
AU = Audit

“D” Grade

The letter grade “D” does not apply to graduate students. Thus, when a graduate student takes a course that is also open to undergraduates and performs at a level equivalent to a “D” grade, this grade cannot be recorded. Such grades are automatically converted to “F.”

“FA” Grade

This letter grade is assigned by the registrar to students who withdraw from a course but do not submit a Drop/Add form or an official notice of withdrawal from the university.

“I” Grade

The grade “I” (incomplete course work) is given, when, due to illness or other extenuating circumstances such as a personal emergency beyond the student’s control, a student has been unable to complete the required course work. The “I” grade is given only after the contract form, Authorization for Grade of Incomplete, has been completed and signed by both the instructor and the student and received by the registrar.

The “I” grade is given only in instances of incomplete course work, such as laboratory exercises, course projects, term papers, etc. Under no circumstances may the “I” be given for the following situations:

■ Absence from a final examination.
■ Student on class list who has never attended class.
■ Student who wishes to do additional post-semester work in order to improve a grade.
■ Student who wishes to repeat the course as auditor, retaking examinations, etc., in order to improve a grade.

The “I” grade must be completed within one semester. If facilities (i.e., laboratory) are required to complete the outstanding work but are not available during the next semester, then one year is the maximum time limit, subject to approval by the instructor.

If the agreements made in the “I” grade contract are not observed or if the “I” grade is not cleared in the time specified in the contract, the grade automatically becomes the grade noted on the “I” contract at the time the “I” contract is signed. If no grade is noted on the contract the “I” grade automatically becomes
a “WI.” Once the “I” grade is changed to “WI,” no other grade change will be accepted. The “WI” grade will be calculated as an “F” in the student’s GPA. The grade of “I” is considered a penalty grade in the calculation of the term GPA.

The grade of “I,” until it is changed, is calculated as if it were the grade of “F.”

“WI” Grade  The registrar assigns this letter grade to students who received an Incomplete (“I”) and failed to meet the criteria or the deadline specified in the “I” contract. It is calculated as an “F” in the student’s GPA.

“IP” Grade The “IP” (In Progress) grade is given at the end of preliminary semesters of multiple-term courses such as Thesis, Project, or Research.

“NE” Grade The “NE” grade is given only by the dean of students or the Office of Graduate Education to students who have been excused from taking a final exam at its scheduled time. In each case, the course instructor is to be informed. (See “Final Examinations” rules listed previously.) If the examination is not taken by the date specified, the grade automatically becomes an “F.” Once the “NE” grade is changed to an “F,” no other grade change will be accepted.

Grades of “NE” given in the fall semester must be made up during the spring semester. “NE” grades given at the end of the spring semester must be made up during the summer recess and not later than two weeks after the beginning of the fall semester. The grade of “NE” is not considered in the calculation of the term GPA.

“P” and “NC” Grades (Pass/No Credit Option) Subject to the limitations listed below, undergraduate students may elect to take courses on a pass or no credit basis, for which the grade is either “P” (Pass) or “NC” (Fail). Grade points will not be assigned for these courses and the “P” or “NC” will not be reflected in the grade point average. “NC” is a failing grade and can be cause for academic action. Courses taken on a Pass/No Credit option can count toward credit-hour and distribution requirements if the grade “P” is received. This option allows a student to take courses outside his or her normal curriculum or minor program that, because of grade considerations, the student otherwise might not consider.

A student may take no more than 12 credit hours of courses designated as Pass/No Credit courses. No more than 6 credits of these may be humanities and social sciences courses used to satisfy the requirements of the undergraduate courses in these fields. A Pass/No Credit course may not be used in the H&SS depth requirement. Courses graded Satisfactory/Unsatisfactory only are not included in the above restrictions. For the five-year B. Arch. curriculum, the Pass/No Credit option is extended, giving a maximum of 16 Pass/No Credit credits.

No course previously failed or specifically required by name or required to be chosen from a list of named courses in the student’s curriculum or minor may be taken on a Pass/No Credit basis. Courses at the 6000 level may not be taken on a Pass/No Credit basis.

A student exercising the Pass/No Credit option must file a form with the registrar before the Friday of the 13th week of the semester. Having elected to take a course on this basis, a student may drop the Pass/No Credit designation by notifying the registrar in writing by the Friday of the 13th week of classes for the semester.

This option is not available to graduate students or nonmatriculated students.

“S” and “U” Grades These grades can only be assigned in courses specifically approved for such grading by the Faculty Senate Curriculum Committee. Examples of such courses are seminar, thesis, or certain general electives, such as Tour of the Solar System, and others.
**“W” Grade** The grade of “W” is assigned when a student is permitted to withdraw from a course after the deadline to drop a course. Only the Office of Graduate Education or the Academic Standing Committee can permit a student to drop a course after the deadline. If permission is granted, the registrar will assign a grade of “W.”

**“Z” Grade** The registrar assigns the grade of “Z” if the instructor does not submit the course grade in time to print the semester grade reports. The student should see his or her instructor for a grade.

**Grade point average**
A student’s grade point average is determined on the basis of the following numbers assigned to the letter grades: A=4, B=3, C=2, D=1, F=0, I=0, FA=0, WI=0. The grades P, U, S, IP, NE, NC, W, and Z are not considered in computing averages. The grade point average is computed by multiplying the number corresponding to the grade in each course by the number of credit hours for the course, totaling these products for the courses taken, and then dividing the sum by the total number of credit hours for the courses considered.

The grade point average for the term is computed at the end of each term. The cumulative grade point average is also computed at the end of each term for the full period of attendance at the university.

All grades are included in computing the average; even those earned in courses not required for the degree sought. Courses taken at institutions other than those at a consortium college, exchange programs, or as part of the Williams and Harvey Mudd Exchange Programs are not included in calculating the GPA although they may qualify for credit.

**Undergraduate Repeating a Course** If an undergraduate repeats a course, both grades are entered on the record. However, course credit will count only once and, although both grades appear on the transcript, the grade received in the repeated course is always the one used in computing the GPA. Senior “F” examination rules remain the same. The grade for a repeated course taken on a Pass/No Credit basis or for which the student receives a grade of “W” or taken at another institution cannot be used in place of the original course grade in calculating the GPA. Students in a premedical or preprofessional program may want to consult with their advisers before repeating a course.

**Graduate Repeating a Course** If a graduate student repeats a course, both grades are entered on the record and the grade points and credit hours corresponding to each are considered in computing the average.

**Scholastic Reports**
Grades are reported to the registrar at the end of each semester. When the grades have been compiled, a report of each student’s standing is sent to the student. Students are responsible for knowledge of their deficiencies and failures and may obtain a copy of their grades from the Registrar’s Office or may view their grades online. Only final semester grades are part of the student’s permanent record. Class rankings for undergraduates are calculated only once a semester, at the time grade reports are printed. Final semester grades and transcripts may be withheld from the student because of an outstanding bill to the Institute or because of pending disciplinary action.

**Curriculum Advising and Program Planning**
A Curriculum Advising and Program Planning (CAPP) report is available online for undergraduate students. This report shows what degree requirements have been met and identifies those requirements that are outstanding.

**Undergraduate Academic Honors**
A student who in any semester attains a grade point average of 3.00 or better and has no grade below C is placed on the Dean’s List for the following semester. Grades below “C” include “I,” “D,” “F,” “FA,” “U,”
and “NC.” No student will be placed on the Dean’s List who takes less than the normal load of 12 credit hours. Thus, a student must have completed at least 12 credit hours with the grades of A, B, or C.

The Dean’s List is compiled at the end of the grading period. No students will be placed on the Dean’s List retroactively except in the case of administrative error or late submission of grade reports by a professor. A student will not be placed on the Dean’s List upon resolving a grade of “I.”

**Undergraduate Graduation Honors**

Undergraduate students with cumulative grade point averages of 3.50 or higher will receive special recognition with the following inscriptions on their diplomas: “Cum Laude” (3.50-3.69), “Magna Cum Laude” (3.70-3.89), and “Summa Cum Laude” (3.90-4.0).

To be eligible for such recognition, the student must have completed two years in residence in the four-year program or three years in residence in a five-year program.

**Academic Standing**

A student is considered in good academic standing if the student is making satisfactory progress toward his or her educational goals. Students not making satisfactory progress will be suspended or dismissed from the university. The university serves students from diverse educational backgrounds and interests and recognizes the individual differences in educational goals between matriculating and nonmatriculated students, between full-time and part-time students, and between graduate and undergraduate students.

**Undergraduate Academic Probation**

Students are placed on academic probation as a warning that they are in jeopardy of losing their good academic standing. Students are informed of their probationary status by a letter from the director of the Advising and Learning Assistance Center at the end of the semester. Academic and extracurricular restrictions may be placed on them so that they can concentrate on their academic programs.

A student whose grade point average for any term falls below 1.50 is placed on academic probation automatically. In addition, any student whose cumulative grade point average falls below the following specified averages is automatically placed on probation: freshmen—1.50 at the end of the fall term or 1.60 at the end of the spring term; sophomores—1.70 at the end of the fall or spring term; juniors and seniors—1.80 at the end of the fall or spring term.

Probation is removed when the following minimum requirements are met during a term in a program of not less than 12 credit hours: freshmen—1.80 grade point average for the term and a cumulative grade point average of 1.60; sophomores—1.80 grade point average for the term and a cumulative grade point average of 1.70; juniors and seniors—1.80 grade point average for the term and a cumulative grade point average of 1.80.

A student on academic probation may have that status removed at the end of the summer session if he or she maintained a grade point average of 1.50 during the previous term and has raised his or her cumulative average to the following prescribed levels: entering sophomore year, 1.60; entering junior year, 1.70; entering senior year, 1.80.

**Undergraduate Academic Suspension and Dismissal**

The Committee on Academic Standing reviews the records of students subject to suspension or dismissal. The committee is authorized to suspend or dismiss any student who:

- Fails to qualify for removal from probationary status at the end of a term.
- Has been on probation for two separate terms and is subject a third time to probationary status.
- Fails three or more courses in any one term.
Undergraduate Disciplinary Suspension or Expulsion
A student whose behavior is in violation of university regulations is subject to disciplinary action. This may result in disciplinary suspension or expulsion from Rensselaer. These disciplinary actions may become a permanent part of the student's record. A student who is expelled for disciplinary reasons cannot apply for readmission.

Graduate Academic Suspension and Dismissal
The Office of Graduate Education will review the records of students recommended for suspension or dismissal by the department chair. The student will be notified in writing by the Office of Graduate Education of any decision to suspend or dismiss. A student who is dismissed from a graduate program is not eligible for readmission or for a change of curriculum except under conditions stated in the letter of dismissal.

Nonmatriculated Undergraduate Student Eligibility
The Advising and Learning Assistance Center reviews the records of nonmatriculated undergraduates each semester to determine if the student is performing satisfactorily. A student whose academic performance is not satisfactory as determined by the director of the Advising and Learning Assistance Center and the Committee on Academic Standing will not be permitted to continue at Rensselaer. Also, nonmatriculated students are permitted access to courses on a space available basis.

Nonmatriculated Graduate Student Eligibility
The records of nonmatriculated graduate students will be reviewed each semester to determine if the student is performing satisfactorily. If it appears that the student is not performing satisfactorily, the academic department will be consulted, if appropriate, and it may be determined that the student not be permitted to continue at Rensselaer. Also, nonmatriculated students are permitted access to courses on a space available basis.

Activities Eligibility Requirements
In order to participate in activities sponsored by the Rensselaer Union, the student must pay an activities fee. Certain activities such as intercollegiate athletics may have special requirements such as minimum credit hour registration, graduate or undergraduate status, etc.

Students on academic probation risk being dismissed from the university if they continue without improvement and should, therefore, examine carefully time committed to extracurricular activities.

A meeting for this purpose must be arranged between the student and a member of the Dean of Students Office by the second week of the semester following that in which the student was placed on academic probation. The student is responsible for arranging this meeting.

Withdrawal from Rensselaer
To leave the Institute in good standing, an undergraduate must submit a letter to the dean of students and a graduate student must submit a letter to the Office of Graduate Education stating the reasons for withdrawal and the student’s last day of residence on campus.

Students who withdraw prior to the eighth week of the semester will receive no grades for the semester. Students who are permitted to withdraw after the eighth week of classes will receive the grade of “W” in all courses.

The student who must withdraw for medical reasons may be exempt from this rule if the medical director determines that it is advisable for the student to withdraw.

Students who withdraw without informing the dean of students or the Office of Graduate Education will receive a grade of “F” in all courses. Undergraduates will be subject to action by the Committee on Academic Standing.
Leave of Absence
Students who wish to spend a period of time away from Rensselaer may request a leave of absence. In order to be considered for a leave, undergraduate students must submit a letter to the dean of students, graduate students to the Office of Graduate Education, stating his or her reasons for the request and the length of leave desired. Undergraduate leaves are normally given for up to one year.

For financial aid purposes only, a leave of absence is limited. Once the allowable period of time has expired students are considered withdrawn.

Leaves of absence are usually granted only during the first eight weeks of the semester and no grades are recorded. Exceptions to this rule are medical reasons or when, in the dean's judgment, other extremely extenuating circumstances exist. Students who are granted a leave of absence after eight weeks will receive grades of “W” in all courses.

Students may request an extension of their leave of absence by writing to the dean of students or the Office of Graduate Education.

Ordinarily, a leave of absence from the Office of Graduate Education does not afford the student extra time to complete the degree. An exception may be made where the leave of absence has been approved for medical, military service, or maternity reasons. In these cases, the student may submit a request to the Office of Graduate Education for additional time to complete the degree. Such an extension usually equals the amount of time spent on leave but may not exceed two years.

Undergraduate Readmission of Students Dismissed for Academic Reasons
Students who have been dismissed from the Institute for academic reasons may apply for readmission after one full academic term (not including summer school) has elapsed. The Committee on Academic Standing makes all readmission decisions concerning academically dismissed undergraduate students. Requests for readmission should be on file at least two months prior to the term in which readmission is desired. Transcripts and course descriptions of work taken elsewhere must be submitted as part of the readmission process. Applications for readmission should be received from and returned to the Advising and Learning Assistance Center.

Undergraduate Readmission of Students Suspended for Disciplinary Reasons
Students suspended from the Institute for disciplinary reasons may reapply one month prior to the end of their suspension. Approval for readmission may be obtained from the Office of the Dean of Students.

Undergraduate Readmission of Students in Good Standing
Students who have been permitted to withdraw in good standing or who have been granted a leave of absence will ordinarily be readmitted upon request of the director of the Advising and Learning Assistance Center.

Graduate Readmission
Graduate students desiring readmission must have the approval of the Office of Graduate Education. The student must fill out a Graduate Change of Status form, which is available in the Registrar’s Office. A student requesting readmission, will be required to have departmental approval. Departments may require reapplication.

Medical Determinations
The medical director will make final decisions regarding readmission or continuance in the university when medical factors are a consideration.
Academic Information and Regulations

Academic Prizes

The date in parentheses indicates the year in which the prize was established.

The Macdonald Prize (1890) The prize, established by Charles Macdonald, Class of 1857, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in civil engineering who has demonstrated outstanding ability in academic work and gives promise of outstanding professional success.

The Macfarlane Prize (1924) The prize, established by Mrs. Walker D. Hines in memory of her father, Graham Macfarlane, Class of 1872, consists of the net annual income from the Macfarlane Fund. It is awarded to the student who has presented the best computer graphics project during the work of the first year.

The Class of 1902 Research Prize (1927) Established by the Class of 1902. It is awarded at Commencement to the senior who presents the best thesis involving research in any branch of engineering or science.

The Ricketts Prizes (1928) The prizes, five in number, consist in each case of the net annual income from $2,000. Three of the prizes were established by Palmer C. Ricketts, Class of 1875, who served Rensselaer for 50 years as instructor, professor, director, and president. They are awarded at Commencement to a senior in mechanical engineering, to a senior in electric power or electrical and systems engineering, and to a senior in chemical engineering. Other prizes were established in 1935 and 1936 by President Ricketts’ widow, Vjera C. Ricketts. They are awarded at Commencement to a senior in the School of Architecture and to a senior in aeronautical engineering. The conditions are the same as those governing the award of the Macdonald Prize.

American Institute of Architects Medal (1934) The American Institute of Architects each year awards a silver medal and a book to the member of the graduating class in the School of Architecture who is outstanding in scholarship, personality, and promise of a successful professional career.

The Ray Palmer Baker Prize (1937) The prize, established by bequest of Vjera C. Ricketts, widow of President Ricketts, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in management engineering. The conditions are the same as those governing the Macdonald Prize.

The Matthew W. Del Gaudio Award (1937) The New York Society of Architects awards this prize annually to a graduating student in architecture who has shown excellence in total design.

The William Pitt Mason Prize (1939) The prize was established by friends and former students of William Pitt Mason, a graduate in the Class of 1874 and professor of chemistry and chemical engineering at Rensselaer for 50 years. The prize consists of the net annual income from $2,000 and is awarded at Commencement to a senior in the Department of Chemistry. The conditions are the same as those governing the Macdonald Prize.

The Mary A. Earl McKinney Prizes (1941) These prizes, established by Dr. Samuel P. McKinney, Class of 1884, consist of the net annual income from $9,000. They are awarded in the form of first and second prizes in two contests, one for freshmen, and the other for all undergraduates. These contests are designed to test proficiency and improvement in English. The contests were originated by Homer H. Nugent, who served Rensselaer for 27 years as professor of rhetoric and head of the Department of English.

The Caird Prize (1945) Established by James M. Caird, Class of 1895, and Barbara J. Caird, the prize consists of the net annual income from $2,000. It is awarded at Commencement to the senior who has
demonstrated outstanding ability in environmental engineering. In a year when no senior is eligible, this award may be made to a graduate student who, by high achievement in academic work and demonstrated qualities of character and leadership, gives promise of outstanding success in professional practice in environmental engineering.

The Matthew Albert Hunter Prize in Metallurgical Engineering (1951) An annual award based on the income from funds contributed by former students of Dr. Hunter, the prize is awarded annually to the senior in materials engineering who has demonstrated outstanding ability in academic work leading to a career in that field.

The Wynant James Williams Prize in Electrical Engineering (1954) An annual award based on the income from funds contributed by friends and former students of Prof. Williams, the prize is awarded annually to a senior in electric power or electrical and systems engineering for outstanding scholarship, personality, and promise.

The Harriet R. Peck Prize (1954) An award established by friends of Miss Peck, head librarian of Rensselaer from 1912 to 1947. Presented to a fifth-year student in the School of Architecture for the best solution of a problem in architectural design. The prize is awarded in selected years.

The Alpha Rho Chi Medal (1955) An annual award established by Alpha Rho Chi, a professional architectural fraternity, the medal is given to a member of the graduating class in the School of Architecture for leadership, service rendered to the school, and promise of professional merit.

The Scott Mackay Award (1958) An annual award based on the income from funds contributed by former students of Prof. Mackay, the award is made to a senior in materials engineering who has given time and effort to the service of others without seeking recognition or acclaim, and who has completed the academic program at Rensselaer creditably.

The Arthur M. Greene Prize (1960) Established by J. Erik Jonsson, Class of 1922, in memory of Dr. Arthur M. Greene, professor of mechanical engineering from 1907 to 1922, this prize consists of the net annual income from $5,000. It is awarded at Commencement to a senior in mechanical engineering who, in the opinion of the professors in the department, has demonstrated the all-around qualities most likely to lead to professional distinction.

The J. Erik Jonsson Prize (1960) Established by J. Erik Jonsson, Class of 1922, the prize consists of the net annual income from $5,000 and is awarded at Commencement to a senior who has spent at least three years at Rensselaer and has achieved the highest academic record in the class.

The Harold N. Trevett Award (1960) An annual award based on the income from funds contributed by friends and former students of Prof. Trevett, the prize is awarded annually to a senior in electric power or electrical and systems engineering for outstanding scholarship in electric power or electrical and systems engineering subjects during the junior and senior years.

The G. Howard Carragan Award (1961) An annual award based on the income from funds contributed by friends and former students of Prof. Carragan, the prize is awarded to a senior in the Department of Physics for outstanding scholarship.

The W. Franklin Spafford Prize (1961) Established by an anonymous donor in honor of the first head of the Department of Management Engineering. This prize is awarded at Commencement to a graduate student in management who has demonstrated high scholastic ability and has made a substantial contribution to that field.

The Joseph L. Rosenholtz Prize (1963) An annual award based on the income from funds contributed by friends and former students of Prof. Rosenholtz, the prize is awarded to a senior for outstanding work
in earth sciences. Should no student qualify for the prize in any one year, the funds available for the prize may be used for related purposes as determined by the Board of Trustees.

The Thomas Archibald Bedford Prize (1964) Established by Clay P. Bedford in memory of his father, the prize is awarded at Commencement to a graduate student in civil engineering who has demonstrated high scholastic ability and has made a substantial contribution to the field. The selection is made by the provost upon recommendations from the Office of Graduate Education. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.

The John and Mary Cloke Prize (1964) This prize is an annual award from the income of a retirement gift given to Prof. and Mrs. Cloke by students and associates of Dr. John B. Cloke, a member of the chemistry faculty for 45 years. Prof. Cloke established the prize to be awarded at Commencement to a graduating senior in the Department of Chemistry who is continuing in chemistry, medicine, or biological science, and who has made a distinguished record, especially in the department.

The Livingston W. Houston Citizenship Award (1964) Established by Clay P. Bedford, the prize is given in memory of Livingston Waddell Houston, 11th president of Rensselaer. It is awarded at Commencement to a student who, in the opinion of a committee consisting of the president of the university, the provost, dean of students, director of athletics, and director of the student union, is considered the “First Citizen of the College.” The recipient must rank high in character, leadership, scholarship, and athletic ability. Should no student qualify for the prize in any one year, the funds available for the prize may be used for related purposes as determined by the Board of Trustees.

The Allen B. DuMont Prize (1969) Established by the Allen B. DuMont Foundation in memory of Dr. DuMont, this prize is awarded at Commencement to a graduate student in electric power or electrical and systems engineering who has demonstrated high scholastic ability and has made a substantial contribution to that field. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.

The Max Hirsch Prize (1972) The prize, established by Prof. Edith H. Luchins in memory of her father, consists of the net annual income from $2,000. It is awarded at Commencement to a senior in the Department of Mathematical Sciences who has demonstrated outstanding ability in academic work and gives promise of outstanding success in a career in mathematical sciences.

The Michael A. Sadowsky Prize (1972) This prize was established by former students and friends of Dr. Sadowsky, professor emeritus of mechanics. It is awarded at Commencement in selected years to a master’s degree candidate in mechanics for outstanding scholarship and a demonstrated ability in the application of mechanics.

The Ralph Ernest Huston Prize (1973) The prize was established by Antoinette K. Huston and sons, Peter, Kenneth, Richard, and T. Michael, in memory of Dr. Ralph Huston, professor of mathematics from 1934 to 1969. It is awarded at Commencement to the first- or second-year graduate student in the Department of Mathematical Sciences who has demonstrated unusual promise and ability as a teacher. Should no student qualify for the prize in any one year, the funds available may be used for related purposes as determined by the Board of Trustees.

The Moles’ Award (1973) The award, consisting of a prize of $100 and an award certificate, is given by the Moles, a national association of men engaged in engineering construction. It is given to a student in engineering whose academic achievement and enthusiastic application show outstanding promise for personal development leading to a career in construction engineering and management.
The Charles D. Dyce Prize (1975) The prize was established by friends in memory of Charles D. Dyce, Class of 1972. It is to be awarded to a student in the School of Engineering who, at the conclusion of the freshman or sophomore year, has demonstrated high scholastic ability and involvement in extracurricular activities and indicates potential for constructive leadership.

The Erwin R. Gaerttner Prize (1975) The Gaerttner Prize is awarded to a senior majoring in nuclear engineering or engineering physics who intends to pursue graduate study in that field. The award consists of the annual income from funds contributed by friends and former students of the late Prof. Gaerttner and is bestowed in recognition of general excellence in scholarship, personal character and attitudes, and promise of outstanding performance in research related to nuclear engineering and engineering physics.

The Lt. Charles D. Dyce Award (1976) Established in memory of Lt. Dyce, Class of 1972, this award is presented to a freshman or sophomore cadet in the Army Reserve Officers Training Corps who has demonstrated high leadership potential and outstanding military bearing and whose superior performance has served to support cadet corps activities. Selection is made in a manner prescribed by the chairman of the Department of Military Science.

The Leopold L. Balleisen Prize (1976) Established by Donald H. Balleisen in memory of his father, a graduate in the Class of 1918. For a senior who has won a varsity letter in his or her senior year and one other year and, of those thus qualified, stands highest academically in the senior class.

The Hillard B. Huntington Award (1976) The prize was established by friends and former students of the late Hillard B. Huntington, professor emeritus of physics. It is awarded at Commencement to an outstanding graduate student in physics.

The Lewis S. Coonley Prize (1978) An annual award established by friends and former students of Prof. Coonley, the prize is awarded to one or more graduating seniors to honor achievement that betokens success in the practice of chemical engineering process design.

The Clarence E. Davies Award (1978) Sponsored by the Hudson-Mohawk Section of the American Society of Mechanical Engineers (ASME), in honor of Col. Davies, a 1914 graduate of Rensselaer who was ASME executive secretary from 1934 to 1957, this award is presented at Commencement to an outstanding senior in Mechanical Engineering.

The Henry J. Nolte Memorial Prize (1978) The prize, established in memory of Henry J. Nolte, who attended Rensselaer in the class of 1919, consists of the net annual income from $1,100. It is awarded at Commencement to a baccalaureate or master’s degree candidate in electrical and systems engineering who has done an outstanding engineering research or design project.

The Joaquin B. Diaz Memorial Prize (1978) Established by friends, family, and colleagues in memory of Dr. Joaquin B. Diaz, the Albert Einstein Professor of Science at Rensselaer from 1967 to 1978, this award is presented to a graduate student who shows ability and enthusiasm for research in mathematics.

The Del and Edith Karger Dissertation Prize in Management (1978) This prize is awarded to a graduate student in the School of Management whose original publication is judged an outstanding contribution by a committee of faculty and alumni.

The L. David Walthousen Award (1979) This award is presented annually to a senior in the Department of Nuclear Engineering and Engineering Physics who shows promise of excellence in the experimental aspects of nuclear engineering. The award consists of the annual income from funds contributed by friends and former students of the late L. David Walthousen, supervisor of the RPI Critical Facility.
The Myron P. Laughlin Prize (1980) The prize, established by Myron P. Laughlin, consists of income from a $1,000 mortgage bond. It is awarded to the student who has written the best pre-engineering laboratory report.

W. H. Bauer Doctoral Prize in Chemistry (1981) This prize is awarded to the candidate who has an exceptional graduate record, has carried out meritorious doctoral thesis research and shows outstanding promise in the field of chemistry. The prize is derived from the income earned from an endowment established by friends and colleagues of Walter H. Bauer, professor of chemistry 1934-72 and dean of science 1960-72.

The Willie Stanton Award (1981) Established by the Rensselaer Union, the award is in honor of William P. (Willie) Stanton, Class of 1972 (hon.), a dishwasher and cook who served the academic and social needs of Rensselaer students for over 45 years. It is presented annually to the senior who is judged to have contributed the most to the service of the student body. The selection committee consists of the vice provost for student affairs, the dean of students, and the director of the Rensselaer Union.

The Karen & Lester Gerhardt Prize in Science and Engineering (1982) This prize was established to honor a full-time engineering or science doctoral candidate, who by the originality and insight of his or her work emphasizes the tradition of excellence that is Rensselaer.

The Edwin J. Holstein Memorial Award (1983) This prize was established to recognize outstanding academic achievement in economic science.

The Paul B. Daitch Award (1984) An annual award based on the income from funds contributed by his family, friends, and colleagues in memory of Professor Paul B. Daitch, the prize is awarded at Commencement to the graduating biomedical engineering senior who combines both outstanding scholarship and level of service to RPI and/or the community, in keeping with Dr. Daitch's interest in public service.

The Paul E. Hemke Award (1985) Sponsored by the Northeastern New York Section of the American Institute for Aeronautics and Astronautics, in honor of Dr. Paul E. Hemke who founded the Aeronautical Engineering Department at Rensselaer. The award is presented at Commencement to a senior in Aeronautical Engineering in recognition of outstanding academic achievement and promise for a successful professional career.

The Delmar W. Karger Award in Management (1986) This award is made to the outstanding graduating master’s student in management based upon academic record and leadership, as judged by a committee of faculty and alumni.

The Epsilon Delta Sigma Award (1986) An annual award established by Epsilon Delta Sigma, the Honorary Management Society, given to an undergraduate or graduate management student who has demonstrated outstanding service to the School of Management.

The Paul A. McGloin Prize (1989) An annual prize established in honor of Professor Paul McGloin, scholar and teacher in the computer science and mathematical sciences departments from 1955 to 1989. The prize is given to an outstanding senior in computer science.

The Robert McNaughton Prize (1989) An annual prize established in honor of Professor Robert McNaughton, scholar and teacher in the computer science and mathematical sciences departments from 1967 to 1989. The prize is given to an outstanding graduate student in computer science.
The Roland Walker Prize (1989) This prize was established by friends and former students of Roland Walker, professor emeritus of biology. The prize is awarded to a senior in biology for outstanding scholarship.

The Del and Ruth Karger Dissertation Prize in the Department of Decision Sciences and Engineering Systems (1991) The prize is awarded at Commencement to a doctoral degree candidate in DSES whose dissertation is deemed outstanding.

The Delmar W. Karger Award in the Department of Decision Sciences and Engineering Systems (1991) The award is made at Commencement to a master's degree candidate in DSES whose master's work—including a project or thesis—is deemed outstanding.

The U.W. Marx Prize (1991) The award is given by U.W. Marx, a general contractor and construction management firm in Troy, NY. It is awarded for the best undergraduate project in civil engineering during the academic year.

The PPG Industries Foundation Management Systems Award (1991) An annual prize established by PPG Industrial Foundation awarded to an outstanding senior in the area of management systems.

The Walter Eppenstein ’52 Graduate Teaching Assistant Award (1991) Established by friends and colleagues of Walter Eppenstein, professor emeritus of physics, to honor his contributions to education at Rensselaer. It is awarded to one or two graduate students for outstanding contribution to our teaching program.

The Charles M. Close ’62 Doctoral Prize (1992) The prize is based on income derived from contributions by members of the electrical, computer, and systems engineering faculty in honor of their colleague Professor Charles M. Close. The prize is awarded annually to a doctoral candidate in electrical, computer, and systems engineering who has done outstanding work as a researcher and teacher, and who shows promise of a distinguished academic or research career.

The Robert G. LaFleur Geology Prize (1993) The prize was established by friends of Professor Robert G. LaFleur for students demonstrating an excellent record in, commitment to, and promise in the field of environmental geoscience.

The Edward J. Kilcawley Prize (1994) The prize was established to perpetuate the memory of Professor Edward J. Kilcawley, a visionary environmentalist, a “man before his time” and to reward a graduate student following his field by Frank R. Sherman, BCE Class of 1939, for whom “Kil” was a mentor, an inspiration, and a life-long good friend. It is awarded at Commencement to a recipient of the degree of Master of Civil Engineering who has pursued his studies in environmental issues, is possessed of the qualifications required for the MacDonald Prize, has been elected to memberships in Tau Beta Pi and the Society of the Sigma Xi, and is a native born citizen of the United States.

The Val Carlson ’52, Architect, AIA, Award (1997) This endowment fund established by Val Carlson ’52 is presented annually to the most improved student graduating from the School of Architecture with a Bachelor of Architecture degree. Preference is given to students from the state of Connecticut. If no person from Connecticut qualifies, then students from the New England states will be considered.

The Stanley I. Landgraf Prize ’46 (1998) An annual prize established to honor Stanley Landgraf, Rensselaer trustee, Acting President, and friend of the Computer Science Department. The prize is given to a computer science major who excels in leadership skills and academic achievement.

Center for Finance & Technology Award (1999) An annual prize awarded to an academically outstanding undergraduate management student with a concentration in Finance.
The Jack Hollingsworth Prize (1999) An annual prize given to honor Jack Hollingsworth, professor of mathematics. This prize is awarded to a computer science student who made a major contribution to the educational program at Rensselaer.

The Severino Center Award in Entrepreneurship (2000) An annual prize given to an outstanding undergraduate management student with a concentration in technological entrepreneurship.

The Glenn Martin Mueller ’64 Prize (2000) An annual prize established to honor Glenn Martin Mueller, Rensselaer Trustee and graduate, Class 1964. A leading venture capitalist in Silicon Valley, Glenn was a champion of the entrepreneur, funding many successful start-up companies. This prize is given to a computer science major who is deemed to be the most entrepreneurial.

The George H. Handelman Award for Graduate Study in Applied Math (2000) This award is given to a graduating senior (in any field) who shows promise in applied mathematics and has been admitted to a graduate program in Applied Mathematics.

The Dr. Johanna Maas Chemistry Teaching Assistant Award (2000) This award is presented annually to one or more graduate students for outstanding service in the teaching program of the Chemistry Department. It was established by Sonja Krause, Class of 1954, and others in memory of Dr. Johanna Zelie Maas, chemist, physician, Holocaust survivor, and humanitarian.

Architecture Faculty Award (2001) Faculty award to a graduating student who has demonstrated exceptional all-around capacity and promise for a successful career in architecture.

The Zelda and David G. Gisser Prize in Biomedical Engineering (2002) An annual prize established by Zelda Gisser in memory of her husband, David G. Gisser. It is awarded to a biomedical engineering graduate student whose dissertation is considered exemplary in the area of experimental work.
In its efforts to shape tomorrow’s leaders, Rensselaer’s faculty has created innovative interdisciplinary curricula. Students are encouraged to work in inter- and cross-disciplinary programs that allow them to combine scholarly work from several departments or schools.

**Applied Science** ........................................................................................................pp. 385

The Master of Science degree traditionally has been in a single subject matter, e.g. chemistry, physics, or mathematics. However, the working environment that college graduates face today and will face in the future is one in which their jobs increasingly bridge more than one area of specialization. The M.S. in Applied Science program is based upon Rensselaer’s belief that science graduates of the past few decades and most current graduates are not educated adequately for today’s interdisciplinary world. Options exist in many areas of science.

**Biochemistry and Biophysics** .................................................................................pp. 386

Two such closely related fields as biochemistry and biophysics are a logical choice for combination into an interdisciplinary degree program. Biochemical and biophysical research is advancing the frontiers of research in the basic life sciences and making possible advances in more applied fields such as medicine and agriculture. Rensselaer’s B.S. in Biochemistry and Biophysics provides exceptional preparation for graduate school and/or employment in various sectors of the rapidly developing biotechnology industry. It also provides an excellent background for students planning careers in medicine. An M.S. degree is also available in this interdisciplinary field and is ideal preparation for jobs in biotechnology, pharmaceuticals, and other related industry sectors.

**Bioinformatics and Molecular Biology** ...............................................................pp. 390

Biotechnology and information technology are emerging new fields that are changing the world. Anticipating the demand for graduates with a range of skills covering mathematics, chemistry, and physics, Rensselaer developed a B.S. degree program that provides solid background in all of these disciplines. At the program’s core are courses in the theory and practice of bioinformatics that deal with topics such as database design and search algorithms, sequence alignment, sequence analysis, and molecular modeling. This core includes a molecular biology sequence and training in drug discovery.

**Ecological Economics, Values, and Policy** .............................................................pp. 280

The B.S. degree combines ecological economics, environmental policy studies, and social and cultural theory and practice. Offered by the Department of Economics and the Department of Science and Technology Studies, the program in Ecological Economics, Values, and Policy (EEVP) satisfies the curriculum requirements for the B.S. programs in both departments. The program combines the best of both departments: economic analysis and a broader humanities and social science analysis that emphasizes the roles science and technology play in today’s global economy and culture.

The professional master’s program is aimed at early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector who are looking to upgrade their skills and advance their careers. The program helps students to acquire the skills they will need to address the complex multidisciplinary problems any society faces in such areas as environment and health and sustainable development.
Electronic Media, Arts, and Communication (EMAC) .......................................................pp. 278
The EMAC degree combines communication theory and practice with electronic media arts studio and theory. This program combines offerings in the Department of Language, Literature, and Communication and the Arts Department.

Environmental Science ...........................................................................................................pp. 394
The challenge of keeping the Earth safely inhabitable while still providing for an ever increasing population and its expanding needs ensures an ongoing demand for environmental scientists. Meeting this challenge requires broader perspective than any single discipline affords. In fact, expertise is necessary beyond just the sciences. Rensselaer’s B.S. in Environmental Science addresses these challenges with a multifaceted program.

Environmental Studies ............................................................................................................pp. 283
To face the challenges of environmental problems, students will need more than the specialized knowledge of a single discipline. The Environmental Studies program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies. Students who enter Rensselaer in the Environmental Studies Program will take a broad range of basic courses in their first two years. They will then choose one of five majors: economics (with an ecological economics focus), environmental engineering, environmental science (with a concentration in a specific area of science), hydrogeology, or science, technology, and society (with an environmental focus).
All the majors in the program offer their own environmental minors, and the School of Architecture and the Lally School of Management and Technology offer special environmental courses as well.

Information Technology .........................................................................................................pp. 293
Rensselaer’s unique cross-disciplinary degrees in Information Technology combine an innovative information technology curriculum with courses in other disciplines to give students the broad base of skills that industry is seeking. The program offers dual competencies: a grounding in information technology and expertise in a concentration such as management, the arts, engineering, architecture, science, and medicine. At Rensselaer, IT is understood in the broadest sense to incorporate the computing and communications industries, including hardware and software; the information, communications, and entertainment services; and the research and application of IT in and to all fields. The program leads to a Bachelor of Science in Information Technology and a Master of Science in Information Technology.

Interdisciplinary Science ............................................................................................................pp. 398
Always encouraging of students’ interests outside the traditional disciplines and career paths, Rensselaer offers this B.S. program that allows for the combination of sciences in innovative ways. In addition it provides the opportunity to combine science with more humanistic studies such as management, law, education, communication, public service, economics, policy-making, or community affairs.

Interschool Minor in Energy ....................................................................................................p. 285
Rensselaer offers this interschool minor as an opportunity for students in any undergraduate major to learn about a wide variety of issues involved in understanding energy. It includes fundamental courses in architecture, engineering, management, science, and the humanities and social sciences.
Minds and Machines ........................................................................................................... pp. 286

The Minds and Machines (M&M) program, which is closely affiliated with the Rensselaer Artificial Intelligence and Reasoning Laboratory (RAIR Lab), offers students a number of options for the B.S. degree. Course work and research are designed to prepare students to make smarter machines and to design the machines that make people smarter. As industry and government increasingly produce and deliver their products and services in computer-mediated environments, the demand is increasing for people who understand human intelligence, machine intelligence, and the social and organizational aspects of the interface between human and machine systems. For more information consult www.rpi.edu/dept/ppcs/MM/mm.uc.html.

Multidisciplinary Science ......................................................................................................... pp. 400

Increasingly, college graduates with traditional discipline oriented backgrounds are discovering that their jobs are bridging more than one area of specialization. Rensselaer’s M.S. and Ph.D. programs in multidisciplinary science are designed to help such individuals function more effectively in such multidisciplinary environments. Through these programs, students interact with faculty representing a variety of disciplines and participate in interdisciplinary research programs that bridge not only science disciplines but also science and engineering.

Product Design and Innovation .............................................................................................. pp. 288

Product Design and Innovation merges the technical with the creative and stimulates originality. A dual major in one of three fields (Mechanical Engineering, Building Science, and IT) and Science and Technology Studies combines engineering disciplines, STS courses, and design studios. A dual major in Building Sciences (School of Architecture) and Science and Technology Studies combines architecture and building science disciplines, STS courses, and design studios. The program in Product Design and Innovation (PDI) is jointly offered by the Schools of Engineering, Architecture, and Humanities and Social Sciences. It offers three tracks; the first satisfies the requirements for the B.S. program in both Mechanical Engineering and Science, Technology, and Society (STS); the second satisfies the requirements for the B.S. programs in both Building Science and STS, and the third satisfies the requirements for IT and STS. For more information, consult www.rpi.edu/dept/sts/pdi.
Table of Contents

Degree Programs 101
Overview of Undergraduate Programs 102
Overview of Graduate Programs 102
Interdisciplinary Programs and Research 125
School of Architecture

Dean: Alan Balfour
Associate Dean: Mark Mistur
Chair, Graduate Programs: Peter Parsons
Director, Lighting Research Center: Mark S. Rea

School of Architecture home page: http://www.rpi.edu

Significant changes are occurring within the discipline and profession of architecture in the areas of globalization, interdisciplinary teamwork, and emerging technologies. Along with a strong creative focus, these issues are at the core of Rensselaer’s undergraduate and graduate architecture programs. The school offers extensive international study programs in locations such as Italy, India, and China; a culture that encourages study and research between disciplines; a studio environment that supports the most ambitious applications of information-based design and technology while encouraging critical innovation. A strong permanent faculty of 15 professors and a complement of clinical and adjunct professors drawn from research and practices in New York, Boston, and Montreal center their instruction on design, which is the core of the undergraduate experience.

These same qualities characterize Rensselaer’s several areas of graduate study in architecture. Apart from the professional masters degree that is designed for those with undergraduate degrees in other fields, the School offers five areas of master’s level specialization: Architectural Acoustics, Building Conservation, Informatics and Architecture, Lighting, and Workplace Design. Each of these focuses on aspects of technology appropriate to Rensselaer and incorporates program elements of Rensselaer’s nationally renowned Lighting Research Center, a preeminent laboratory for lighting research. The School of Architecture participates in an interdisciplinary Ph.D. program allowing for advanced study and research between architecture and appropriate areas of science, engineering, and the humanities.

To both its undergraduate and graduate students, Rensselaer’s School of Architecture offers an outstanding collection of resources and state-of-the-art facilities. Rensselaer’s Architecture Library, the only branch library on the campus, is located at the physical center of the school and is a major student, faculty, and professional resource. This library contains over 30,000 books and periodicals, both domestic and foreign, as well as a loan collection of 90,000 slides on contemporary and historical buildings, structural design, building technology, city planning, and fine arts. It also holds a collection of maps and architectural drawings. The collection is growing to include such electronic media as videos, microfiche, and architecture-related software. (More information can be found at the library’s web site: http://www.rpi.edu/dept/library/html/architecture.)

Specialized facilities and equipment that enhance school activities include a testing room with a Hemianechoic chamber; the Binaural Listening test station, the Lee Harris Pomery ’54 Advanced Visualization Lab; Synthetic Environments Lab, the Laboratory of Human-Environment Interaction Research; the Electronic Studio 305; the Solar and Microclimate Laboratory, the School of Architecture Workshop, Field Study Facilities, Optical Tools, the Community Outreach Partnership Center in the Gurley Building, and various other laboratories. They are generally available to all students, although in some cases training may be required and some equipment is reserved for advanced students.

This combination of excellent programs and modern facilities endows all School of Architecture graduates with a distinctive creativity, pragmatism, independence, and a progressive outlook that makes them highly sought for architectural practice.
Degrees Offered

Architecture B.Arch., M.Arch.
Building Conservation M.S.
Building Science B.S., M.S.
Concentration in Architectural Acoustics
Concentration in Workplace Design
Informatics and Architecture M.S.
Lighting M.S.

Overview of Undergraduate Programs
The School of Architecture offers a four-year Bachelor of Science in Building Sciences and a five-year Bachelor of Architecture degree. The Bachelor of Architecture is a professional degree accredited by the National Architecture Accrediting Board. Approximately 60 students are admitted directly into the program each year.

As a professional school designed for those ready to begin serious architectural study in the first year, the School of Architecture’s admissions decisions are based on three criteria: overall academic excellence, creativity demonstrated through work in the arts and other areas, and maturity and personal motivation. The School encourages visiting the campus and the Green Building, home of the School of Architecture, along with a faculty interview. All undergraduate program applicants must also provide a portfolio. For portfolio requirements visit www.arch.edu/undergraduate.

Students who have completed some architecture course work at other schools may apply for transfer to Rensselaer. Upon acceptance, transfer students are placed at an appropriate level in the professional program based on a review of their transcript, course descriptions, and work portfolio.

Overview Graduate Programs
Rensselaer’s School of Architecture offers master’s level graduate programs.

Master’s Programs
The School of Architecture offers a number of distinct master’s degrees. The Master of Architecture I is a first professional degree. It is accredited by the National Architecture Accrediting Board for students already holding at least a baccalaureate degree in another field. This degree’s course of study parallels much of the course and studio requirements for the Bachelor of Architecture program. Approximately 10 students are admitted to this program annually.

The remaining master’s programs are advanced degrees in architecture, building science, and related fields. They include:

- Master of Architecture II
- Master of Science in Building Conservation
- Master of Science in Building Sciences (Concentration in Architectural Acoustics)
- Master of Science in Building Sciences (Concentration in Workplace Design)
- Master of Science in Informatics and Architecture
- Master of Science in Lighting
Research Innovations and Initiatives

**Acoustics of performance venues and classrooms**
The School of Architecture faculty is renowned for its acoustic consulting expertise in designing world-class performance venues and for its academic research in advanced techniques for computational modeling of room acoustics. Examples of current research include modeling and perception of coupled acoustical spaces, perception of room coloration, under-balcony environments, and cross-modal interaction between visual and acoustical stimuli. Architecture faculty and graduate students have traveled to the Bass Performance Hall in Fort Worth, Texas, to measure acoustical energy coupling with monaural and binaural receivers. A more recent emphasis is on classrooms where poor acoustics are detrimental to learning. Research and design in this area includes computer modeling and experimentation with scale models as well as measurement and analysis in existing facilities. Ease of Hearing in Various Classroom Geometries, a recently completed thesis project, involved modeling various geometries using acoustics prediction software.

**Auralization**
The acoustical analog of visualization aims to recreate sound fields from computational models of spaces. Current core research includes the development of more accurate mathematical models for room acoustics, determination of accurate scattering and diffraction coefficients for performance-hall design and modeling, and subjective studies on the effect of sound quality on human performance, including productivity, ease of hearing, and hearing comfort.

**Electronic enhancement of acoustical communication over large distances**
This work focuses on the development of “acoustic telepresence systems” that will provide an unmatched auditory sense of presence across distances. This research is an essential aural counterpart to current research in computer-mediated visual technologies, with possible applications in teleconferencing, distance education, and virtual reality.

**Electronic tuning of room acoustic properties**
Electronic tuning can be very helpful in adapting the venue to the events taking place in it (music performances of different genres, conferences, etc.). Such dynamic tuning is very important to insure optimum acoustic quality in multipurpose spaces.

**Measurement techniques for room acoustics**
New measurement technologies can be used for more effective representation of sound fields, leading to a better understanding of physical phenomena and aiding acousticians in the design process.

**Synthetic sensing and synthetic environments**
Current research includes the experimental development of alternative sensory methods for individuals and the development and testing of immersive and augmented electronic environments for teleperformance and design collaboration. A guiding principle of the research is the complementary nature of media, computation, space, and the body rather than the substitution of human skills or spatial conditions with computer technology.

**Computer-mediated design processes**
This research area is primarily concerned with Computer-Aided Design and the redefinition of the design process. The computer is envisioned as a medium opening up new possibilities for architectural and urban design, rather than as a tool for performing well-known tasks more quickly and cheaply. New design algorithms, new roles of computing in the client-designer-builder network, and new design processes are at the core of research in this area.
Simulation, data, and design
Simulation in architecture must react not only to complex physical criteria, but also be sensitive to social, cultural, and political concerns that are not easily codified into a simulation algorithm. Research focuses on the development of new simulation methods that provide creative, legible, and interactive feedback to designers, planners, and others involved in architectural and urban design. Facilities specific to this research are the Lee Harris Pomeroy ’54 Advanced Visualization Lab, the Synthetic Environments Lab, Studio 305, the Solar and Microclimate Laboratory, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

Light and health
The Lighting Research Center continues to seek funding to expand research initiatives in the area of light of health. Investigations include the role of lighting in the mitigation of diseases and disorders such as Alzheimer’s disease and Seasonal Affective Disorder (SAD) and the interaction of lighting with the human circadian and other biological systems. This research has far-reaching implications in the areas of medical research, photobiology, biotechnology, engineering, and related sciences.

Solid state lighting
Solid state lighting is one of the fastest growing areas in lighting technology today with wide implications for all areas of lighting including architecture, transportation, and information technology. The Lighting Research Center has developed core competencies in this area and works to expand research in solid state lighting development and application.

Energy policy
With growing need for electricity nation-wide and increasing societal pressure to avoid building new generation plants and transmission lines, there is increasing need for research into the area of “demand/response” technologies. These technologies can be used to decrease electric demand at peak times quickly without negatively impacting employee comfort or productivity. Lighting plays a key role in this area, and the Lighting Research Center seeks funding for research to assist the development of demand/response technologies and policies.

Intelligent roadway systems
With the increasing complexity and congestion of roadways throughout the United States and the development of new communication and information technologies, lighting plays a key role in the transmission of information to drivers. The Lighting Research Center seeks funding to expand research into the development of lighting as part of intelligent roadway systems.

Faculty*
Professors
Balfour, A.—M.F.A. (Princeton University); architecture and urban history and society.
Boyce, P.—Ph.D. (University of Reading); human factors.
Bronet, F.—M.S. (Columbia University); architectural design, structures technology, interdisciplinary design. President Elect, ACSA.
Haviland, D.—M.Arch. (Rensselaer Polytechnic Institute); building industry, management, economics.
Kroner, W.—M.Arch. (Rensselaer Polytechnic Institute); resources and sustainable architecture, advanced building technologies, futurism, and architectural design.
Leslie, R.—M.Arch. (Rensselaer Polytechnic Institute); lighting, daylighting, environmental comfort technologies.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Rea, M.—Ph.D. (Ohio State University); vision science; lighting theory and applications.

Associate Dean
Mistur, M.—M.S. Building Conservation, B.Arch. (Rensselaer Polytechnic Institute); architectural design, practice, technology. (Clinical)

Associate Professors
Bell, D.—M.Arch. (University of Virginia); architectural design, theory, and history.
Krueger, T.—M.Arch. (Columbia University); human-environment interaction, design.
Massie, W.—M.Arch (Columbia University); architectural design, computer applications and emerging technologies, architectural practice.
Parsons, P.—B.Arch. (Cornell University); architectural design, theory, and history.
Warriner, K.—B.Arch. (University of Florida); architectural and urban design and theory.

Assistant Professors
Dyson, A.—M.Arch (Yale University); architectural design, structures technology, multidisciplinary design theory and ecology.
Lonsway, B.—M.Arch. (Columbia University); architectural theory and electronic media.
Torres, R.—Ph.D. (Chalmers Tekniska Hoegskola, Gothenburg, Sweden); architectural acoustics, auralization of sound fields, subjective effects of room acoustics.
VanDessel, S.—Ph.D. (University of Florida); emerging materials and material development, sustainable architectural technologies.

Clinical Professors
Oatman, M.—M.F.A. (University of Albany); B.F.A. (Rhode Island School of Design); drawing, design, painter and installation artist.
Riebe, D.—M.S. (Columbia University); architectural design, emerging technologies and practice. practicing licensed architect.

Emeritus Faculty
Pertuiset, N.—Hons. Dipl. Arch. and Theory (Architectural Association); architectural design and theory.
Quinn, P.—M.Arch. (University of Pennsylvania); theory and architectural design, institutional and community facilities.
Williams, G.—M.Arch. (Rensselaer Polytechnic Institute); architectural design and practice.

Adjunct and Visiting Faculty
Abbate-Gardner, C.—M.Arch. (University of Rome); architectural and urban design, practice, and Italian studies.
Akashi, Y.—Ph.D. (Musashi Institute of Technology); human factors in lighting.
Andrasek, A.—M.S. Advanced Architecture Design (Columbia University); research and design theory, architecture.
Bedford, S.—Ph.D. (Columbia University); architectural history, regulatory compliance.
Bierman, A.—M.S. (Rensselaer Polytechnic Institute); mesopic vision, color vision, lighting controls, measurement of lighting efficiency.
Boucher, D.—B.Arch (Rensselaer Polytechnic Institute); partner, historic preservation, building conservation.
Bullough, J.—M.S. (Rensselaer Polytechnic Institute); psychological and biological effects of light, lighting for transportation, technology transfer.
Byszewski, V.—D.Sc., Ph.D., M.S.(Warsaw University), Ph.D. (Polish Academy); lighting technology.
Carpentier, Jr., D.—B.A. Historic Preservation (Empire State College); historic preservation.
Cawley, F.—B.F.A. and B. Landscape Architecture (Rhode Island School of Design); historic preservation, landscape architecture, and urban design.

Ellinger, J.—M. Arch. (Columbia University); design.

Faccia, A.—M.S. (University of Virginia); urban planner.

Figueiro, M.—M.S. Lighting, (Rensselaer Polytechnic Institute); lighting alumna with a background in architectural design and construction management.

Fleisher, S.—B.A. (Northeastern University); furniture design.

Foulks, W.—B.Arch. (University of Michigan) M.A. (Columbia University); restoration and preservation of historic buildings.

Freidman, D.—B.S. (Rensselaer Polytechnic Institute); historic buildings engineering practice.

Hartgen, K.—M.Arts (University of New York, Albany); artifact preservation.

Hill, K.—M.Eng. (Cornell University); B.S.E. (Princeton University); practicing structural engineer.

Hoffman, D.—B.F.A. (Carnegie Mellon University); theater, technical theater, stage design, stage lighting, theatrical engineering.

Holmes, O.—B.S. Mathematics (State University College Oneonta) B.S. Mechanical Engineering (Syracuse University), HVAC, building systems, energy management.

Leeser, T.—B.Arch., M.Arch. (Technische Universitaet, Darmstadt, Germany); architecture, design theory, research experimentation.

Levin, R.—Ph.D. (Stanford University); lighting optics, lighting application, nonionizing radiation.

Lopez, D.—Dipl. Arch. (Architectural Association); architectural design theory and practice.

McColgan, M.—Ph.D. Physics (University of Alabama in Huntsville); B.S. Optics (University of Rochester); light pollution, outdoor lighting, optical modeling.

Miller, N.—B.S. (Massachusetts Institute of Technology); energy-efficient lighting for residential and commercial uses, lighting quality and human factors.

Miner, D.—M.S. (Columbia University); preservation law.

Mintz, N.—B.S. (Pratt Institute) M.S. (Columbia University); urban design, historic preservation.

Morante, P.—B.S. Electrical Engineering (Norwich University); marketing and electric power markets.

Moyer, J.—B.A. (Michigan State University); architectural, functional, aesthetic, and energy-efficient lighting.

Nelson, B.—B.A., B.S. (Rensselaer Polytechnic Institute); professional practice, community planning, project management.

Pepi, R.—B.A. Liberal Arts (Syracuse University); American history, architectural history.


Reilly, S.—B.Arch., B.S. (Rensselaer Polytechnic Institute), architectural design, practice, preservation technology.

Shaver, P.—B.A. Liberal Arts (Syracuse University); American history, architectural history.

Schwitter, C.—M.S. (Massachusetts Institute of Technology); structural and building services engineering.

Vance, J.—B.Arch. (Auburn University); integration of lighting systems into architecture.

Van Derlofske, J.—Ph.D. (University of Alabama in Huntsville); illumination systems, optical design, optical computer modeling, prototype development.

Vasconez, S.—M.S. (Rensselaer Polytechnic Institute); lighting education, retail and residential lighting design.

Vural, S.—B.Arch (Fine Arts Academy, Istanbul) M.Arch (Pratt Institute); history, theory, and architectural design and practice.

Wu, J.—M.Arch. (Harvard Graduate School of Design); architectural design, theory, and practice.
Research Architecture

Ebbing, C.—M.S.E.E. (SUNY at Buffalo); industrial acoustics, research special noise control.

Shimizu, Y.—M.S. (Tokyo Institute of Technology); acoustical design, active sound field control technology, psychological acoustics.

Research Associate Professor

Narendran, N.—Ph.D. (University of Rhode Island); remote source lighting, fiber-optic sensors, geometric and physical optics.

Visiting Scholar

Oksanen, J.—Technician Engineer of Electricity (Helsinki Institute of Technology); lighting education, lighting design, lighting research.

Undergraduate Programs

The School of Architecture offers two distinct undergraduate degrees. The five-year Bachelor of Architecture (B.Arch.) curriculum centers on the design studio and culminates in a year-long research and design project. Computing, theoretical, technological, and historical issues are progressively integrated into the design projects beginning in the first year. Projects range in scale and form, but relate to issues in contemporary culture with a focus on globalization and urban contexts.

The second undergraduate curriculum is the four-year B.S. in Building Sciences, which prepares students for the broad range of building industry roles and opportunities. Rensselaer’s excellence in science and technology permits specialization within the Building Sciences program. Students enrolled in the Bachelor of Architecture program may, anytime after the second year, apply for transfer to the four-year Building Sciences degree program. Rensselaer’s Building Sciences students may also choose to concentrate in Information Technology as it relates to the building industry, energy efficiency in buildings, project and construction management, or lighting. In addition, independent studies are available in special topic areas. Another option is the interdisciplinary Product Design and Innovation dual degree program offered jointly between Building Sciences and the School of Humanities and Social Sciences’ Department of Science and Technology Studies.

Each of these degree programs are described in detail below.

Students in both School of Architecture undergraduate programs are required to complete courses in the arts, sciences, humanities, and social sciences as part of the Institute core requirements. The core courses are structured to provide exposure and breadth to each of these areas.

In addition to Institute-wide academic regulations outlined earlier in this catalog, the following pertain to the bachelor’s program in architecture:

■ Advancement in Design—Students not passing a required design course may not advance to the next course in the design sequence. The architecture faculty will review students earning grades of D or lower in required design courses. A student earning a D or lower in any subsequent required design course must either repeat the course or take another course specified by the faculty before advancing to the next course in the design sequence. Students who fail to earn a grade of C or better in the repeated or specified course, or who earn a third grade of D or lower in design, may not continue in the design sequence. A student earning an F in any course, must repeat the course.

■ Retention of Student Design Work—All drawings and models done by students as part of the instructional program are the property of the Institute until they have been released by the instructor. The School of Architecture at its option may retain certain works for academic purposes.
Baccalaureate Programs

Bachelor of Architecture (B.Arch.) Curriculum

This five-year undergraduate professional program is a first professional degree accredited by the National Architectural Accreditation Board. The program is for a limited number of qualified students committed to the study of architecture. These students are admitted directly to the professional degree program and begin studies in architecture in the first year.

The National Architectural Accreditation Board (NAAB) accredits the Rensselaer School of Architecture’s Bachelor of Architecture program and its Master of Architecture program. The following statement is included in the catalog, pursuant to the requirement of the NAAB:

In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accreditation Board, which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes two types of degrees; the Bachelor of Architecture and the Master of Architecture. A program may be granted a six-year, three-year, or two-year term of accreditation, depending on its degree of conformance with established educational standards.

Master’s degree programs may consist of preprofessional and undergraduate degree and a professional graduate degree, which, when earned sequentially, comprise an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

Rensselaer’s B.Arch. program incorporates and interconnects the following important elements:

- Design—Design and the design studio form the core of all architecture degree programs. The design studio brings together the many aspects of architecture and presents a wide range of design issues, beginning with the development of the tools, skills, and judgments that underlie the production of architecture.
  The skills area emphasizes that the hand is as important as the computer in the representation of ideas. The ability to freely manipulate space, surface, structure, and texture is central to the reformation of architecture. The tools component develops confidence in the technologies that form architecture and are essential support to creativity. Finally, the judgments aspect is developed through projects premised on the continual evolution of architecture as a manifestation of the social, economic, political, and technological forces within the culture. All the design studios draw broadly on the exceptional range of urban and architectural contexts near the campus; from the historic towns in upstate New York to great cities of the region such as New York, Boston, Montreal, and Philadelphia.

  In the design studio there are no singular, provable, or perfect answers to any of the problems presented. Students explore and develop their design proposals based on their growing knowledge of architecture and their emerging ability. The early semester-long studios introduce students to the full range of issues, skills, and judgments encountered in design and initiate and reinforce design as critical inquiry. The remaining studios focus on significant concerns in architecture. They are “vertical” in that they include students in different class years, and they present choices of project and faculty. Among these is the design development studio, in which a prior project is subjected to detailed structural, mechanical, construction materials, and professional practice considerations.

- History and Theory—A required five-course sequence presents the diversity of architectural works and ideas relative to the contexts within which architecture emerges and to key historical and theoretical issues in the field. Following this sequence, students may take additional advanced architectural history/theory electives as a part of their professional or free elective selections and are required to take at least one history elective from the listing of professional electives.
Technology and Building Science—Technological issues are introduced from the beginning as essential to the conception and creation of architecture. New technologies can be the generative of form and inhabitable space. A series of six required technology courses consider both qualitative and quantitative views of building technologies. These include statics and strength of materials; basic structures and framing; design of wood, steel, and concrete structures; criteria for selecting building materials and systems; environmental systems, including heating, ventilation, air conditioning, plumbing, and electrical systems; sensory environment, including the luminous, acoustical, and tactile environments; codes and contract documents. Following this sequence, students may take additional advanced technology and building science electives as a part of their professional or free elective selections. Integration of technological considerations is central to many of the studios with a focused emphasis on integrating building technologies and the act of creating in the required upper level design development studio.

Computing—Computer proficiency is central to the future of architecture. From the first year, students are able to expand their knowledge and skill through course work with key computing concepts and applications—in some cases integrated within the design studios—and through independent experimentation in the many computer labs at the School and Institute. Apart from well-supported general-purpose labs, the School offers high-end multimedia environments within the many design studios. Students have access to the latest in three-dimensional design software, virtual reality programming tools, and video and multimedia production hardware and software to investigate the value of these technologies to critical design practice. Students may experiment with immersive 3-D, VR collaboration, or video and animation-based investigations of architectural and urban form. Advanced software from film production and VR-based manufacturing is available in an environment designed for digital collaboration.

These elements are provided through both required courses as well as many professional electives and topics in such areas as architectural and urban history and theory, technology, computing, building economics, community design, practice and management, architectural lighting, and acoustics in architecture. Professional degree students must complete at least 12 credits from these offerings by either building on a specific interest or by sampling the breadth and diversity inherent in the field. A minimum of four credits must be from a designated list of history electives. In addition to regularly offered electives (described in the back of this catalog), the faculty offers a number of topics or experimental courses as professional electives. Sample courses include, but are not limited to:

- Advanced Structures Technology
- Advanced Technologies Seminar
- American Building—17th–19th Centuries and 20th Renaissance
- Architectural Acoustics 1 and 2
- Architecture and Urban Design in the Italian Renaissance
- Bedford Technology Seminar
- Building Conservation 1 and 2
- Building Engineering Design Seminar
- Construction Industry Seminar
- Design: Built Ecologies and Natural Systems
- Drawing Historic Structures
- Electronic Media: Critical Visualization
- Electronic Media: Physical Design Processes
- Emerging Materials and Material Development
- Evolution of Housing in the 20th Century
- Geometry in Architecture
- Human Factors in Lighting
- Lighting Design
- Lighting Technology
- Philosophies of Space in a Digital Culture
- Presentation [re] Presentation + Memory
- Preservation Theory
- Recording Historic Structures
- Re-Painting the White Cube
- Seeing Digital
- Simulation
- Sustainable Community Design
- Understanding Computer Mediated Design
- Workshop: Material Exploration and Fabrication
The five-year B.Arch. program concludes with an individually initiated, planned, and developed comprehensive project. Planning begins in the fourth year through an exchange of ideas with and a critique by a faculty adviser and review committee. The resulting proposals form published faculty statements of interest combined with the students' experiences and areas of special concern. These may emerge from a synthesis of previous work that applied gained knowledge to advanced issues or, alternatively, experiences to date may be used as a base from which to explore and to innovate. This final year begins with a short competition project in which all participate. An integrated design research phase then lasts the remainder of the first and throughout the second semester.

The final project is an opportunity to develop a point of view about architecture and its place in the world; to question conventions, habitual responses, and routine approaches to architectural design; and to investigate issues that the student sees as significant to architecture.

A sample template of the B.Arch. curriculum structure is provided below. Please note that special circumstances such as dual majors may involve some variation from this template.

**Bachelor of Architecture Curriculum**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCH-2200</td>
<td>Design Studio (2)</td>
<td>4</td>
<td>Architecture Design 1(4)</td>
</tr>
<tr>
<td>ARCH-2110</td>
<td>The Building and Thinking of Architecture 1 2</td>
<td>4</td>
<td>ARCH-2510</td>
</tr>
<tr>
<td>MATH-1500</td>
<td>Calculus I</td>
<td>4</td>
<td>Materials and Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The Building and Thinking of Architecture 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PHYS-1050</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Physical Principles of Design</td>
</tr>
<tr>
<td>Second Year</td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCH-2130</td>
<td>Contemporary Design Approaches</td>
<td>2</td>
<td>ARCH-2140</td>
</tr>
<tr>
<td>ARCH-2220</td>
<td>Architecture Design 2 (5)</td>
<td>6</td>
<td>Architecture Design 3</td>
</tr>
<tr>
<td>ARCH-2330</td>
<td>Structures 1 3</td>
<td>4</td>
<td>ARCH-2230</td>
</tr>
<tr>
<td>ARCH-2350</td>
<td>Hum. or Soc. Sci Elective</td>
<td>4</td>
<td>Environ. and Ecological Systems</td>
</tr>
<tr>
<td></td>
<td>Construction Systems</td>
<td>2</td>
<td>Math Elective</td>
</tr>
<tr>
<td>Third Year</td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCH-4240</td>
<td>Hum. or Soc. Sci Elective</td>
<td>4</td>
<td>ARCH-4250</td>
</tr>
<tr>
<td>ARCH-4330</td>
<td>Architecture Design 4 (Urban)</td>
<td>6</td>
<td>Architecture Design 5</td>
</tr>
<tr>
<td>ARCH-4140</td>
<td>Structures 2 1</td>
<td>4</td>
<td>ARCH-4740</td>
</tr>
<tr>
<td></td>
<td>Modernity in Culture and</td>
<td>4</td>
<td>Building Systems and Environment</td>
</tr>
<tr>
<td></td>
<td>Architecture</td>
<td></td>
<td>ARCH-4560</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Materials and Enclosure</td>
</tr>
</tbody>
</table>

1 IHSS-1970 will fulfill the Institute writing requirement.

2 Four credits of the Hum. or Soc. Sci core requirements are embedded within The Building and Thinking of Architecture sequence: ARCH-2110 and ARCH-2120.

3 Four credits of the Institute core Science requirements are embedded within the technology sequence: ARCH-2330, ARCH-2360, ARCH-4330, and ARCH-4740.

4 In general, the recommended course is MATH-1620 offered only in the spring.
In regard to the above template, please note that studios are sequential with the exception of the Design Development studio, which may be taken any time after the completion of the urban studio (Architecture Design 4) and before B.Arch. Final Project 1. Students are required to complete eight credits in Math, 12 in Science, and 20 in Humanities and Social Sciences from an extensive list of course offerings (see Institute core requirements for greater detail). In addition, students have 12 credits of free electives which can be used to further focus on a concentrated area of study, pursue a minor or dual major, or as a means of further broadening exposure to a range of disciplines.

Discipline specific sequences embedded in the curriculum are detailed below.

Technology courses: ARCH-2330 Structures 1 is sequential and prerequisite to ARCH-4330 Structures 2; and ARCH-2360 Environmental and Ecological Systems is sequential and prerequisite to ARCH-4740 Building Systems and Environment.


ARCH-2110 The Building and Thinking of Architecture 1, ARCH-2120 The Building and Thinking of Architecture 2 are prerequisites to ARCH-2130 Contemporary Design Approaches.

All Undergraduate students should develop a plan of study with their faculty adviser. The degree requires 168 credit hours.

\[ \text{Fourth Year} \]

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4690</td>
<td>Case Studies ...........................................4</td>
</tr>
<tr>
<td>ARCH-4260</td>
<td>Architecture Design 6 .................................6</td>
</tr>
<tr>
<td></td>
<td>Professional Elective ..................................4</td>
</tr>
<tr>
<td></td>
<td>Elective ..................................................4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4040</td>
<td>Cities/Land ............................................4</td>
</tr>
<tr>
<td>ARCH-4300</td>
<td>Design Development ......................................6</td>
</tr>
<tr>
<td>ARCH-4540</td>
<td>Professional Practice (^1) ..........................2</td>
</tr>
<tr>
<td></td>
<td>Elective ..................................................4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4990</td>
<td>B.Arch. Final Project 1 ((3)) .......................6</td>
</tr>
<tr>
<td></td>
<td>Research /Methods (1) ..................................</td>
</tr>
<tr>
<td></td>
<td>Competition (2) .........................................</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ............................4</td>
</tr>
<tr>
<td></td>
<td>Elective ..................................................4</td>
</tr>
<tr>
<td></td>
<td>Professional Elective ...................................2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4990</td>
<td>B.Arch. Final Project 2 ...............................6</td>
</tr>
<tr>
<td></td>
<td>Science Elective .......................................4</td>
</tr>
<tr>
<td></td>
<td>Professional Elective ..................................4</td>
</tr>
<tr>
<td></td>
<td>Professional Elective ...................................2</td>
</tr>
</tbody>
</table>

\(^1\) Taken in the same semester as ARCH-4300.
**Bachelor of Science in Building Sciences Curriculum**

The four-year Bachelor of Science degree in Building Sciences prepares students for the broad range of roles and opportunities presented by the building industry. Students enrolled in the B.Arch. program may, anytime after the second year, apply for transfer to Building Sciences. The building sciences focus on the design and construction of building systems such as structures, enclosures, environmental systems, lighting, and acoustics as well as their management, performance, and building diagnostics.

Students in the Building Sciences program declare a concentration and submit a plan of study at the end of the second semester. The plan of study must be approved and filed with the Building Sciences program director. For the first two semesters, students follow the same curriculum as the B.Arch. students. For the remaining six semesters, they take concentration electives in place of design courses. Concentrations include computer applications, lighting, construction management, and advanced technology assessment. The degree requires 126 credit hours.

### Building Science Curriculum

#### First Year

<table>
<thead>
<tr>
<th><strong>Fall</strong></th>
<th><strong>Credit hours</strong></th>
<th><strong>Spring</strong></th>
<th><strong>Credit hours</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2110</td>
<td>The Building and Thinking of Architecture 1’</td>
<td>ARCH-2120</td>
<td>The Building and Thinking of Architecture 2’</td>
</tr>
<tr>
<td>ARCH-2200</td>
<td>Design Studio</td>
<td>ARCH-2210</td>
<td>Architecture Design 1</td>
</tr>
<tr>
<td>MATH-1500</td>
<td>Calculus I</td>
<td>PHYS-1050</td>
<td>Physical Principles of Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ARCH-2510</td>
<td>Materials and Design</td>
</tr>
</tbody>
</table>

#### Second Year

<table>
<thead>
<tr>
<th><strong>Fall</strong></th>
<th><strong>Credit hours</strong></th>
<th><strong>Spring</strong></th>
<th><strong>Credit hours</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>ARCH-2360</td>
<td>Concentration Elective</td>
</tr>
<tr>
<td>Professional Elective</td>
<td>2</td>
<td>ARCH-230</td>
<td>Env. and Ecol. Systems 1</td>
</tr>
<tr>
<td>ARCH-2330</td>
<td>Structures 1’</td>
<td>Arch-2360</td>
<td>Science Elective</td>
</tr>
<tr>
<td>MGMT-2100</td>
<td>Statistical Methods</td>
<td>Arch-230</td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

#### Third Year

<table>
<thead>
<tr>
<th><strong>Fall</strong></th>
<th><strong>Credit hours</strong></th>
<th><strong>Spring</strong></th>
<th><strong>Credit hours</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4330</td>
<td>Structures 2’</td>
<td>ARCH-4510</td>
<td>Construction Industry Seminar</td>
</tr>
<tr>
<td>ARCH-4330</td>
<td>Science Elective</td>
<td>ARCH-4740</td>
<td>Bldg. Sys. and Env. 1</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Professional Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1. Four credits of the Hum. or Soc. Sci core requirements are embedded within The Building and Thinking of Architecture sequence: ARCH-2110 and ARCH-2120.
2. IHSS-1970 will fulfill the Institute writing requirement.
3. Four credits of the Institute core Science requirements are embedded within the Technology sequence: ARCH-2330, ARCH-2360, ARCH-4330, and ARCH-4740.
The degree requires 126 credit hours. All undergraduate students should develop a plan of study with their faculty adviser.

Concentrations
All Building Science program concentrations require five four-credit-hour courses (or equivalent) that are approved by a concentration coordinator and the director of the Building Sciences program. Concentration options and their associated courses include:

**Lighting**
- LGHT-4840 Human Factors in Lighting (4)
- LGHT-4770 Lighting Technology (4)
- LGHT-4230 Lighting Design (4)
- LGHT-4790 Lighting Applications (4)
- LGHT-4830 Light (4)

**Building Systems and Products**
- ARCH-4810 Advanced Technology Seminar (2)
- MGMT-1100 Intro. to Management (4)
- ARCH-4940 Adv. Ind. Projects in Arch. and Env. (4)
- ARCH-4940 Advanced Individual Projects in Arch. (2)
- MGMT-4430 Marketing Principles (4)
- HVCC* Construction Materials (2)
- MGMT-4430 Intro. to Computation-Based Design and Programming (4)

**Construction Management**
- ARCH-4810 Advanced Technology Seminar (2)
- MGMT-1100 Intro. to Management (4)
- MGMT-4100 Operations Management I (4)
- ARCH-4940 Adv. Ind. Projects in Arch. and Env. (4)
- CIVL-2040 Professional Practice (3)
- CIVL-4270 Construction Management (3)

**Computer Applications**
- CSCI-1100 Computer Science I (4)
- ARTS-1020 Media Studio: Imaging (4)
- ARCH-4460 Electronic Media: Critical Visualization (4)
- ARCH-4620 Intro. to Computation-Based Design and Programming (4)
- ARCH-4940 Advanced Individual Projects in Arch. for Env. Design (CAD) (4)

*This course is available at Hudson Valley Community College. Contact your adviser for further information.

**Dual Major Programs**
Dual majors are available to students interested in pursuing two majors simultaneously and who can develop an acceptable program of study that meets the requirements for both majors. There are many possibilities, with the most common options combining civil engineering or management with architecture. The interdisciplinary degree in Product Design and Innovation has been specifically developed for Building Science majors and is explained in detail under the heading Interdisciplinary Programs and Research found at the end of the School of Architecture section of this catalog.

**Minor Programs**
The School of Architecture offers minor options for both School of Architecture students and students majoring in other Rensselaer programs. These options are described below.
Architecture
A minor in architecture is directed toward Rensselaer students interested in architecture as a sociocultural phenomenon and/or those envisioning a career in some segment of the building industry. The minor program provides an exposure to architecture—what it is, what it includes, its history, how it is accomplished; and to architects—who they are and how they think and work.

A minor consists of an approved 16-credit program. ARCH-2110 Building and Thinking of Architecture 1 is required but students may select the remainder of the courses to build a concentration in architecture that supports their own disciplinary interests.

Architectural History
The minor in architectural history is open to all Rensselaer students interested in the history of architecture as a sociocultural phenomenon that examines architecture as a cultural artifact. It consists of ARCH-2110 The Building and Thinking of Architecture 1 and upper division architectural history courses. Students who wish to obtain a minor in architectural history must receive approval of their course selections from the program adviser.

Lighting
The minor in lighting gives students the awareness and the confidence to extend their creative work through controlled use of light. The program covers human responses to light, both visual and nonvisual, and the means by which light is produced and controlled. Interactions of light with form, texture, and color are examined in the contexts of daylight, electric lighting, and their integration.

The program comprises 16 credits taken in the Lighting Research Center. Both fall semester courses must be taken before the spring semester courses, and the two spring semester courses must be taken concurrently. The courses required are: LGHT-4840 Human Factors in Lighting; LGHT-4770 Lighting Technology; LGHT-4230 Lighting Design; and LGHT-4790 Lighting Applications.

Special Undergraduate Opportunities
Study Abroad
International study is a defining aspect of Rensselaer’s architectural education and the School of Architecture offers several international semester long programs of study. Offered in Italy, India, and China; these programs are fully integrated with the requirements of the undergraduate degree and have been established in three world cities that will challenge and help to define the future of architecture. Each of these programs is open, by competitive application, to students in their fifth semester and above. Only 20–25 students (B.Arch and M.Arch) are selected each year on the basis of academic accomplishment. In addition to a Rensselaer faculty member who directs these students, adjunct faculty in the host city or institution provide instruction. There is a program fee for participation in each of these programs, which are described briefly below.

- Italy—The Rome semester involves a design studio, an examination of the architectural development of Rome, courses in Italian language and culture, and travel throughout Italy. The program seeks to deepen appreciation of the city and the layers of its culture that have played a seminal role in the development of Western culture and architecture.
- India—The program is based in the School of Architecture CEPT at Ahmedabad, India, a highly respected school for the study of architecture and urbanism. It offers students the opportunity to travel, study, and apply the lessons learned from Indian architecture and Indian history and theory within the context of a major research center.
The semester in Shanghai is based at the School of Architecture at Tongji University, one of the great institutions of China. The program offers joint studios in design with Chinese faculty and students, and travel through central China augments additional courses in Chinese history and culture. In addition, the School of Architecture offers occasional summer study abroad programs to places of special architectural interest. In recent years, these have included visits to Turkey and the Czech Republic.

**Exchange Programs**

Architecture students are eligible to apply for admittance into a student exchange program at the Swiss Federal Institute of Technology (ETH, Zurich). An agreement between Rensselaer and ETH provides for a year of study abroad. Other exchange and study abroad opportunities are also available.

**Summer Studios**

The school offers two six-week studios in the summer session that are open to accepted transfer and entering Master of Architecture students. With sufficient enrollment, an eight-week upper level vertical studio is offered for students enrolling in ARCH-2230 Architecture Design 3 through ARCH-4260 Architecture Design 6.

**Co-op Experiences**

A number of architecture students insert co-op work experiences into their program of study. Work opportunities are available in a wide range of situations, from architecture firms large and small to design groups in industry or institutions. Co-op experiences are an invaluable introduction to practice and strengthen the learning experience. Co-ops can usually earn credit toward the professional Intern Development Program (IDP) requirement.

**Lectures and Exhibits**

Architecture and architectural education advance through full engagement in the world of ideas. The school offers visiting faculty and lecturers and provides field trips, student travel funds, seminars, and exhibitions. Each semester a lecture, exhibition, seminar, and workshop program is created. The lecture and exhibition series presents the work of internationally recognized faculty and practitioners, providing students and faculty with exposure to current and critical ideas influencing the profession. Lectures and exhibitions are open to all Rensselaer students and the local professional community.

**Graduate Programs**

The School of Architecture offers several graduate degrees at the master's level. These include the Master of Architecture I as a first professional degree for students already holding at least a baccalaureate degree in any field of study.

Those who have accredited degrees in architecture and wish to pursue advanced studies related to architecture may seek Master of Architecture or Master of Science degrees as post-professional degrees in the School of Architecture. Master of Science degrees are also available to applicants who have been enrolled in fields related to architecture. The degrees offer the opportunity for advanced, focused, and intellectually rigorous study in architecture and building sciences.

Included among these post-professional master’s programs are the Master of Architecture M.Arch. II, Master of Science in Building Conservation, Master of Science in Building Sciences (Concentration in Architectural Acoustics), Master of Science in Building Sciences (Concentration in Workplace Design), Master of Science in Informatics and Architecture, and the Master of Science in Lighting.
As a degree limited to applicants who have gained a professional degree in architecture, the Master of Architecture II is distinct from the Master of Science. For students entering this program with a five-year first professional Bachelors or Masters degree, the M.Arch. II is one path to a terminal degree (for teaching). Either the M.Arch.II or the M.S. involves a minimum 30 credit hours of study.

Among its offerings, the School of Architecture provides some special seminars of particular benefit to most graduate students, except those studying lighting and building conservation. These include:

- **Research Design Seminar**—Covering the essential bases of research work, whether to assist with the development of a Ph.D. dissertation, Masters Thesis, or Masters Project, this course builds students' critical reading skills and ability to direct a research project creatively and pragmatically. This course introduces students to external researchers who present work in progress and discuss and advise student projects.

- **Graduate Thesis Seminar**—Taken in students' second term, this course provides graduate students from the Architectural Acoustic, Workplace Design, and Informatics and Architecture research programs a forum for publicly presenting and discussing their work.

In addition to the Institute-wide academic regulations outlined in this catalog, the following pertain to graduate programs in architecture:

- **Academic Progress**—To earn the professional M.Arch. Degree students must maintain a B average in the following courses: Design Explorations (ARCH-6110, ARCH-6120 and ARCH-6130), Design Development (ARCH-4300), and Master’s Thesis (ARCH-6990). Students whose cumulative averages for all course work drop below 3.0 will be reviewed for satisfactory progress. The architecture faculty, as part of its academic review process, will review professional M.Arch. students earning grades of C or below. A student earning a C or below in a subsequent required design course must either repeat the course or take another course specified by the faculty before advancing to the next course in the design sequence. Students who fail to earn a grade of B or better in the repeated or specified course or who earn a third C or lower in design may not continue in the design sequence.

- **Retention of Student Work**—All student drawings and models created as part of the instructional program are the property of the Institute until the instructor releases them. The School of Architecture, at its option, may retain certain works for academic purposes.

### Master’s Programs

#### Master of Architecture I

The curriculum for this professional degree program largely overlaps the B.Arch program, albeit in an accelerated manner. It features a distinct individualized pedagogical core through an advanced history and theory course sequence. On average, this degree is completed in three and a half years (one summer plus three academic years).

This degree provides a balanced education in architectural design, history, theory, and technology. As with the undergraduate program, it centers on the design studio where projects address a multitude of design issues through multiple strategies ranging from the design of carefully crafted objects to architecture, landscape architecture, and urban design.

The National Architectural Accreditation Board (NAAB) accredits the Rensselaer School of Architecture’s Master of Architecture three and a half-year program. The following statement is included in the catalog, pursuant to NAAB requirements:

**In the United States, most state registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board, which is the sole agency authorized to accredit U.S. professional degree programs in architecture, recognizes two types of degrees; the Bachelor of**
Architecture and the Master of Architecture. A program may be granted a six-year, three-year, or two-year term of accreditation, depending on its degree of conformance with established educational standards.

Master’s degree programs may consist of preprofessional and undergraduate degree and a professional graduate degree, which, when earned sequentially, comprise an accredited professional education. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

Applicants to this program must have a bachelor's degree, have earned a 3.0 cumulative average (on a 4.0 scale) and have within their undergraduate studies a course in free hand or life-study drawing. They must also have eight to 10 courses in humanities and social sciences, one year of mathematics with at least one course in calculus, one course in physics, and additional courses in the sciences. Course work in the arts and art history is also desirable. A portfolio of creative works and critical commentary on those works is required for admission. Application is made to the Office of Admissions. Students with previous architecture courses will be considered for advanced standing in this program. Enrollment in the initial summer studio is usually necessary to determine placement in the design sequence. For information regarding program tuition and financial aid, please refer to the Tuition and Financial Aid section of this catalog.

Like the B.Arch. program, the M.Arch.I program incorporates and interconnects the important elements of design, history and theory, technology and building science, and computing. For a detailed description of Rensselaer’s approach to these elements, please refer to the Bachelor of Architecture (B.Arch.) Curriculum section.

Also noted within the Bachelor of Architecture Curriculum description is the School’s many professional electives and topics offerings in such areas as architectural and urban history and theory, technology, computing, building economics, community design, practice and management, architectural lighting, and acoustics in architecture. At the master’s level, professional degree students must complete at least 16 credits from these offerings by building on a specific interest or sampling the breadth and diversity inherent in the field. A minimum of four of those credits must be from a designated list of history electives. In addition to regularly offered electives (described in the back of this catalog), the faculty offers a number of topics or experimental courses as professional electives. A sample of these courses can be found on page 109.

The M.Arch. I program concludes with an individually initiated, planned, and developed thesis. Planning begins in the third year and involves an exchange of ideas with and a critique by a faculty adviser and review committee. The resulting proposals are published statements of interest from the faculty combined with the students’ experiences and areas of special concern. These may emerge from a synthesis of previous work applying gained knowledge to advanced issues, or alternatively, make use of experiences to date as a base from which to explore and to innovate. This final year begins with a short competition project in which all participate. An integrated design research phase then lasts the remainder of the first and throughout the second semester.

The thesis is an opportunity to develop a point of view about architecture and its place in the world, to question conventions, habitual responses, and routine approaches to architectural design, and to investigate issues that the student sees as significant to architecture.
To provide the clearest possible picture of the M.Arch.I curriculum structure, a sample template is provided below.

**M.Arch.I Curriculum**

**Summer Session**
The program begins with a 12-week summer session that provides full immersion in architectural design. The summer studio is small and is characterized by intense and highly individualized student-faculty interaction. The graduate professional student uses the summer session to prepare for entry into design at the second-year level in the fall; it also provides an opportunity to evaluate his or her design capacity.

**Summer Sessions 1 - 2**

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Summer Sessions 1 - 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2600</td>
<td>Graduate Design Studio</td>
</tr>
<tr>
<td>ARCH-2610</td>
<td>Graduate Architecture Design</td>
</tr>
</tbody>
</table>

**First Year**

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2110</td>
<td>The Building and Thinking of Architecture</td>
</tr>
<tr>
<td>ARCH-2620</td>
<td>Graduate Architecture Design 2 (5) Computing (1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2120</td>
<td>The Building and Thinking of Architecture</td>
</tr>
<tr>
<td>ARCH-4360</td>
<td>Graduate Architecture Design 4 (Urban)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Second Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4330</td>
<td>Structures 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4300</td>
<td>Design Development</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Third Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6990</td>
<td>Thesis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Credit hours</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6990</td>
<td>Thesis</td>
</tr>
</tbody>
</table>

1. ARCH-6120 and ARCH-6130 address a variety of significant theoretical issues and are taught together. Topics alternate each year.
2. Taken in the same semester as ARCH-4300.
In regard to the above template, please note that studios are generally sequential. ARCH-4300 Design Development studio should be taken after the completion of the ARCH-4360 Graduate Architecture Design 4 (urban) studio and before ARCH-6990 Thesis.

- Technology courses: ARCH-2330 Structures 1 is sequential and prerequisite to ARCH-4330 Structures 2; ARCH-2360 Environmental and Ecological Systems is sequential and prerequisite to ARCH-4740 Building Systems and Environment.
- ARCH-2600 Graduate Design Studio, ARCH-2610 Graduate Architecture Design 1 through ARCH-4360 Graduate Architecture Design 4; and the ARCH-2330 Structures 1, ARCH-2360 Environmental and Ecological Systems, and ARCH-4330 Structures 2 series are prerequisites to ARCH-4300 Design Development studio. ARCH-4740 Building Systems and Environment may be taken concurrently with ARCH-4300 Design Development studio.

A plan of study is required for all graduate students. The degree requires 112 credit hours. Admission with advanced standing can fulfill a significant number of these credits, especially for students who have been enrolled in undergraduate pre-architecture programs or non-accredited professional programs.

**Masters Degrees—Advanced Programs**

Applications to any of these programs should be directed to Rensselaer Admissions. Since a match between student interests and faculty research capabilities is an integral part of this program, applicants must include a focus-of-study proposal and, where appropriate, a portfolio of design and other creative work, with critical commentary, as part of the application.

**Building Conservation**

Applicants to the M.S. in Building Conservation are generally architectural or engineering practitioners who wish to build expertise in historic structures and building conservation. However, the program welcomes graduate students with related degrees and professional experience.

**Master of Building Science Degrees**

**Building Science**

**Architectural Acoustics** Applicants to the M.S. in Building Sciences (Concentration in Architectural Acoustics) are required to submit a portfolio, but prospective students should submit a statement of interest and include some examples of analytical or creative work relevant to their interest in acoustics.

**Workplace Design** Applicants to the M.S. in Building Sciences (Concentration in Workplace Design) must submit a portfolio and focused goal statement. The goal statement must specify areas of design and/or research interests related to the goals of the Workplace Design program. Applicants must also demonstrate familiarity with climate, environmental comfort, and building energy performance analysis and simulation tools. Where evidence of familiarity with any of these areas is insufficient, prerequisite courses may be specified as conditions of admission.

**Informatics and Architecture** Applicants to the M.S. in Informatics and Architecture must demonstrate familiarity with computing. Programming skills are helpful but not required. Where there is insufficient evidence of familiarity with any of these areas, prerequisite courses may be specified as conditions of admission.

**Lighting** Applicants to the M.S. in Lighting should submit a portfolio or other examples of work and a statement of goals and objectives. They are also urged to complete two college-level math courses before applying to the program.
**M.Arch.II** Applicants to this post-professional advanced degree program must hold a professional B.Arch or M.Arch degree. Students within this program develop a special individualized plan of study drawn from the School’s various graduate offering and must receive faculty guidance and approval.

For those accepted as candidates for these advanced Architecture master’s programs, a thesis is the normal requirement for degree completion. However in some subjects, and with faculty approval, degree requirements may be satisfied with either a research project or course work. The general institute criteria for the master's thesis can be found in the Academic Information and Regulations section of this catalogue.

**Master of Science in Building Conservation**

The School of Architecture’s M.S. in Building Conservation graduate program is a two-year, part-time course designed for mid-career professionals who are or intend to be involved in the care, repair, restoration, and adaptation of buildings, urban environments, and rural landscapes.

Both academically and geographically, Rensselaer is well positioned to provide this course of study in historic resources conservation and management. The School of Architecture is noted for its technical emphasis and strong design concerns. Buttressing this foundation for the M.S. in Building Conservation is adjunct and clinical faculty drawn from a coterie of highly qualified preservationists in New York’s historic Capital District, which includes some of the country’s top preservation architects, planners, engineers, conservators, not-for-profit managers, and enlightened public officials. Potential institutional partners in the Building Conservation program include New York state agencies such as the Office of Parks, Recreation, and Historic Preservation and the Departments of State and Environmental Conservation; the Preservation League of New York State; the Hudson Mohawk Industrial Gateway; community-based organizations such as the Troy Rehabilitation and Improvement Program; Heritage corridor programs such as those in the Hudson and Mohawk River valleys; and local and county governments.

The Master of Science in Building Conservation program prepares students to assume responsible employment positions in the preservation, conservation, and management of historic resources. It also provides a thorough understanding of the theory and practice of historic preservation and building conservation. Students receive training in disciplines such as identification and analysis of specific building materials to structural stabilization, restoration, and reuse of historic structures; planning for wise development of entire urban and rural areas; and the legal, economic, and political factors that make these endeavors possible. In addition, they gain real-world, hands-on experience through extensive fieldwork and the program's close affiliation with regional architectural and engineering firms and with not-for-profit, state, and municipal, community-based, educational, and social service agencies.

The program is presented through alternate on-campus, two-day weekend sessions of class and fieldwork for two academic years (September–May) for a total of 30 weekends. It begins with a five-day residency and concludes with a three-day residency each year. This structure allows students to continue working, remain with their families, and pursue other interests while earning their degree. Students are generally expected to be architectural or engineering practitioners. However, the program welcomes graduate students with related degrees and professional experience.

To part-time students, the degree is offered every other weekend and is completed in four semesters over two years. Degree candidates follow the curriculum template outlined below in sequence. Teamwork is encouraged on campus, and students are required to complete 20–25 hours of home assignments between alternate weekend sessions. The M.S. in Building Conservation degree requires 32 credit hours and normally takes two years to complete. Students have access to such facilities as the objects conservation laboratories of the Metropolitan Museum of Art and Building Conservation Associates in New York City, a private museum of nineteenth century buildings in rural Rensselaer County, New York, and Rensselaer’s Libraries and Information Services.
Building Conservation Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH-4640 American Building—17th–19th Centuries</td>
<td>ARCH-4650 American Building—20th Century</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH-46610 Preservation Theory</td>
<td>ARCH-4700 Recording Historic Structures</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH-4670 Building Conservation 1</td>
<td>ARCH-6710 Preservation Design Studio 1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH-6680 Researching Historic Structures</td>
<td>ARCH-6720 Preservation Design Studio 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH-6690 Drawing Historic Structures</td>
<td>ARCH-4680 Traditional Trades and Craftsmanship</td>
<td>2</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4630 Building Conservation 2</td>
<td>ARCH-4680 Historic Preservation Law</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>ARCH-4660 Historical Archeology</td>
<td>ARCH-6640 Contemporary Preservation Practice</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ARCH-4670 Industrial Archeology</td>
<td>ARCH-6620</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ARCH-6650 Architectural Materials Testing</td>
<td>ARCH-6630 Economics of Historic Preservation</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>ARCH-6630 Economics of Historic Preservation</td>
<td>ARCH-4680 Traditional Trades and Craftsmanship</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

The degree requires 32 credit hours.

Master of Science in Building Sciences (Concentration in Architectural Acoustics)

This program of advanced study focuses on the optimization of acoustical quality of performance spaces and other aurally sensitive environments. Research in this area improves understanding of how a space is designed to achieve the best acoustics for a given purpose. The program is geared toward students with a Bachelor’s degree who have interests in acoustics, music, architecture, and/or engineering. Rensselaer offers numerous state-of-the-art facilities related to study in this area including a testing room with Hemianechoic, a Binural listening test station, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

Individuals applying for admission to this program must have a bachelor-level degree (B.Arch., B.S., or B.A.) in Architecture, Engineering, Music, Physics, Mathematics, Computer Science, Acoustics, Electronic Media, Theater Technology, or other related fields. Those with other degrees or experience (e.g., who have worked in the field) and with keen interest in Architectural Acoustics will also be considered. Those receiving an M.S. in Building Sciences (Concentration in Architectural Acoustics) will be well prepared to enter the field at post-entry positions.

Architectural Acoustics Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ARCH-4840 Architectural Acoustics 1</td>
<td>ARCH-4850 Architectural Acoustics 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH-6870 Sonics Research Laboratory 1</td>
<td>ARCH-6880 Sonics Research Laboratory 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ARCH-6460 Stagecraft and Theatre Design 1</td>
<td>ARTS-6xxx Advanced Computer Music and Acoustics</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ARCH-6810 Research Design Seminar</td>
<td>ARCH-6470 Stagecraft and Theatre Design 2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>or approved concentration elective</td>
<td>or approved concentration elective</td>
<td>2</td>
</tr>
</tbody>
</table>

Second Year

| ARCH-6990 Master’s Thesis | ARCH-6990 Graduate Thesis Seminar | 8 |

1 Concentration electives are intended to allow students to take alternative courses with significant relevance to their thesis research. They must be approved by a faculty member of the Acoustics program before inclusion in an Acoustics student’s plan of study.
Possible Concentration Electives include (but are not limited to):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6940</td>
<td>Advanced Individual Projects (e.g., Ind. Study)</td>
<td>1–6</td>
</tr>
<tr>
<td>ARTS-6010</td>
<td>Computer Music Studio</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4610</td>
<td>Vibrations</td>
<td>3</td>
</tr>
<tr>
<td>MANE-4830</td>
<td>Acoustics Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ECSE-4500</td>
<td>Probability for Engineering Applications</td>
<td>4</td>
</tr>
</tbody>
</table>

The degree requires 34 credit hours.

**Master of Science in Building Sciences (Concentration in Workplace Design)**

Workplace Design offers advanced studies related to the design, technologies, and management of the intelligent workplace. Intelligent workplaces are responsive, attractive, and cost-effective business environments. Research and design studies explore the use of advanced and emerging technologies in architecture and their impact on design, human productivity, and environmental qualities. The central question of this program is: “What must be done to design productive environments?” Facilities specific to this concentration include Studio 305, the Solar and Microclimate Laboratory, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

**Workplace Design Curriculum**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credit Hours</strong></td>
<td><strong>Credit Hours</strong></td>
</tr>
<tr>
<td>ARCH-4810</td>
<td>ARCH-6900</td>
</tr>
<tr>
<td>Advanced Technology Seminar</td>
<td>Graduate Thesis Seminar</td>
</tr>
<tr>
<td>..................................</td>
<td>..................................</td>
</tr>
<tr>
<td>ARCH-6810</td>
<td>ARCH-6990</td>
</tr>
<tr>
<td>Research Design Seminar</td>
<td>Master’s Thesis (Preparation)</td>
</tr>
<tr>
<td>..................................</td>
<td>..................................</td>
</tr>
<tr>
<td>Concentration Elective</td>
<td>Concentration Elective</td>
</tr>
<tr>
<td>..................................</td>
<td>..................................</td>
</tr>
<tr>
<td>..................................</td>
<td>..................................</td>
</tr>
</tbody>
</table>

**Fall**  
ARCH-6990 Master’s Thesis ................................4

The degree requires 30 credit hours.

**Master of Science in Informatics and Architecture**

Consider that “informatics” is the thoughtful study of the impacts of information technology on human lives and that “architecture” is one of the primary ways of relating to the environment. The study, then, of their combination can serve as an important juncture in understanding contemporary culture. Informatics and Architecture strives to broaden understanding of architecture as it relates to media culture, advanced building technology, and computation. Coursework requires the explicit integration of critical study and technological development, and only through thoughtfully integrating them can important advances in the field be made. Students are asked to frame their ideas about design practices with progressive concerns for society, the environment, and the future of technological development. By engaging directly with the tools and techniques of computation, students can impact the future of research and practice in these burgeoning design areas. Students satisfy the degree requirements either by completing a masters-level research thesis or through advanced coursework. The research thesis option is open to students currently holding a master’s degree or equivalent or to those who clearly articulate a research project proposal in their application. The coursework option is open to all students currently holding a bachelor’s degree or its equivalent.
The curricula for the two degree options vary slightly, but relies in all cases on a series of core courses developed to provide a critical foundation for the evolving discipline. These courses cover theoretical introductions, technological foundations, and research methods. Facilities specifically related to the M.S. in Informatics and Architecture include The Lee Harris Pomeroy ’54 Advanced Visualization Lab, the Synthetic Environments Lab, Studio 305, the Solar and Microclimate Laboratory, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

Informatics and Architecture Curriculum

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6420 Experimental Research Lab .......</td>
<td>2</td>
<td>ARCH-6900 Graduate Thesis Seminar ...........</td>
<td>2</td>
</tr>
<tr>
<td>ARCH-6810 Research Design Seminar ..........</td>
<td>2</td>
<td>ARCH-6990 Master’s Thesis .....................</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-6400 Philosophies of Space in a Digital Culture</td>
<td>4</td>
<td>Or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ARCH-6980 Master’s Project ...................</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentration Elective .......................</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Term</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6990 Master’s Thesis</td>
<td>4</td>
<td>ARCH-6900 Graduate Thesis Seminar ...........</td>
<td>2</td>
</tr>
<tr>
<td>Or</td>
<td></td>
<td>ARCH-6990 Master’s Thesis .....................</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-6980 Master’s Project</td>
<td>4</td>
<td>Or</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ARCH-6980 Master’s Project ...................</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentration Elective .......................</td>
<td>4</td>
</tr>
</tbody>
</table>

The degree requires 30 credit hours.

Electives

Students within this program pursue elective coursework from across the Institute, depending on their prior experience and intellectual objectives. Following is a sample of electives students have taken to fulfill their degrees:

- Computability and Complexity
- Computational Intelligence
- Economics of Information and Information Technology
- Electronic Media: Physical Design Processes
- Experimental Research Lab
- Gender, Science, and Technology
- History of American Technology
- Interactive Arts Programming
- Introduction to Artificial Intelligence
- IT Policy and Law
- Politics of Space in a Digital Culture
- Simulation of Large Scale Systems
- Technology and Social Theory
- Thinking Digital 3-D Computer Graphics Programming

Master of Science in Lighting

The School of Architecture, in association with the Lighting Research Center, offers a Master of Science in Lighting degree to students who complete a 48-credit, two-year curriculum. This post-professional program is based in the internationally renowned Lighting Research Center, the standard-setting research institute for the lighting industry. This program cultivates both a scientific and artistic understanding of the many issues involved in all aspects of the development of lighting and designing with light. It also offers an M.S. in Lighting to individuals without a first professional degree who wish to work in either lighting design or research.
The first year curriculum provides a broad education that cultivates a scientific and artistic understanding of the interactions of all elements of lighting. The third semester offers opportunities to pursue individual projects under faculty guidance in the Lighting Workshop. The program concludes with a leadership seminar and thesis study.

Graduates may seek leadership roles in practice or they may continue with further, more specialized, doctoral studies in other Rensselaer schools. The curriculum is normally completed in four semesters. Facilities and equipment specific to this program include various Rensselaer laboratories, field study facilities, optical tools, the Laboratory for Human-Environment Interaction Research, the School of Architecture Workshop, and Rensselaer’s Libraries and Information Services.

M.S. in Lighting Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGHT-4830</td>
<td>Light</td>
<td>LGHT-4230</td>
<td>Lighting Design</td>
</tr>
<tr>
<td>LGHT-4770</td>
<td>Lighting Technology</td>
<td>LGHT-4790</td>
<td>Lighting Applications</td>
</tr>
<tr>
<td>LGHT-4840</td>
<td>Human Factors in Lighting</td>
<td>LGHT-6750</td>
<td>Lighting Research Design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>Credit hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LGHT-6760</td>
<td>Lighting Workshop</td>
<td>LGHT-6990</td>
<td>Master’s Thesis</td>
</tr>
<tr>
<td></td>
<td>Independent Studies</td>
<td>LGHT-6780</td>
<td>Lighting Leadership Seminar</td>
</tr>
</tbody>
</table>

The degree requires 48 credit hours.

Master of Architecture
(Post-Professional Degree) Curriculum

Within the Master of Architecture programs there is the opportunity to develop a curriculum specific to an applicant’s interest if there is corresponding expertise in the faculty. This program includes 30 credits of project and course work (including a thesis) and normally requires three semesters to complete.

<table>
<thead>
<tr>
<th>Fall</th>
<th></th>
<th>Spring</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-6810</td>
<td>Research Design Seminar</td>
<td>ARCH-6990</td>
<td>Graduate Thesis Seminar</td>
</tr>
<tr>
<td>ARCH-6990</td>
<td>Master’s Thesis</td>
<td>ARCH-6990</td>
<td>Master’s Thesis</td>
</tr>
<tr>
<td></td>
<td>Electives</td>
<td></td>
<td>Electives</td>
</tr>
</tbody>
</table>

Fall
ARCH-6990 Master’s Thesis

This degree requires 30 credit hours.

Special Master’s Opportunities

Study Abroad (M.Arch 1)
International study is a defining aspect of Rensselaer’s architectural education and the School of Architecture offers several semester-long international programs of study. Offered in Italy, India, and China, these programs are open, by competitive application, to M.Arch.1 students. Only 20–25 students (B.Arch and M.Arch) are selected each year on the basis of academic accomplishment. In addition to
direction from a Rensselaer faculty member, adjunct faculty in the host city or institution provide instruction. There is a program fee for participation in each of these programs, which are described briefly below.

■ Italy—The Rome semester involves a design studio, an examination of the architectural development of Rome, courses in Italian language and culture, and travel throughout Italy. The program seeks to deepen appreciation of the city and the layers of its culture that have played a seminal role in the development of Western culture and architecture.

■ India—The program is based in the School of Architecture CEPT at Ahmedabad, India, a highly respected school for the study of architecture and urbanism. It offers students the opportunity to travel, study, and apply the lessons learned from Indian architecture and Indian history and theory within the context of a major research center.

■ China—The semester in Shanghai is based at the School of Architecture at Tongji University, one of the great institutions of China. The program offers joint studios in design with Chinese faculty and students and travel through central China augments additional courses in Chinese history and culture.

In addition, the School of Architecture offers occasional summer study abroad programs to places of special architectural interest. In recent years, these have included visits to Turkey and the Czech Republic. For specific information regarding admission to the School of Architecture’s graduate programs see the Admissions section of this catalog.

**Course Descriptions**
Courses related to all Architecture curricula are described in the Course Descriptions section of this catalog under the department code ARCH.

**Interdisciplinary Programs and Research**

**Product Design and Innovation**
The dual major program in Product Design and Innovation (PDI) is jointly offered by the Schools of Engineering, Architecture, and Humanities and Social Sciences. The PDI curriculum satisfies the requirements for the B.S. programs in both Building Science and Science, Technology, and Society (STS).

The PDI program prepares students to become innovative designers who will develop and design the advanced products and technologies for the coming century. Built around a design studio every semester, PDI combines the technical, aesthetic, and cultural sophistication of Rensselaer’s building science curriculum with the insight and vision of the humanities and social sciences disciplines in the STS curriculum.

The core of PDI is the design studio that students take every semester, giving them a hands-on opportunity to bring together the two major curricula. The building science curriculum provides a fundamental education in building science and architectural design through basic and advanced courses in structures, environmental and construction systems, as well as physical and theoretical approaches in design. The STS curriculum provides a fundamental education in the economic, ethical, cultural, and political dimensions of product development and innovation, including numerous case studies of successes and failures that will give students the opportunity to learn what it takes to be effective design team leaders. On this basis, the design studios help students to explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.
The design experiences range over a breadth of problems, from larger systemic problems to smaller focused problems, so that students have a broad exposure to all the different applications of design practice. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from conception to implementation. The studios also develop students’ skills in using computers and other advanced tools and techniques, as well as in drawing, visualizing, communicating, and working together. In short, they provide everything necessary to put their creativity to work as leaders of design and innovation, whether it is in a multinational business at the cutting edge of the global market or in a smaller business that creates an unusual solution to a local problem.

### PDI Curriculum in Building Science and STS

<table>
<thead>
<tr>
<th>First Year</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
<td><strong>Credit Hours</strong></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .........................................4</td>
<td>STSH-1110</td>
<td>Introduction to STS .....................4</td>
</tr>
<tr>
<td>ARCH-2110</td>
<td>The Building and Thinking of Arch. ............14</td>
<td>PHYS-1050</td>
<td>Physical Principles of Design ...........4</td>
</tr>
<tr>
<td>ARCH-2200</td>
<td>Design Studio ......................................4</td>
<td>ARCH-2120</td>
<td>The Building and Thinking of Arch. .......2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ARCH-2510</td>
<td>Materials and Design .................2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
<td><strong>Credit Hours</strong></td>
</tr>
<tr>
<td>IHSS-2500</td>
<td>Design Studio 1 ................................4</td>
<td>ENGR-2050</td>
<td>Introduction to Eng. Design ........4</td>
</tr>
<tr>
<td>STSS-2200</td>
<td>Engineering, Design and Society ..............4</td>
<td>ARCH-2360</td>
<td>Env. and Ecol. Systems ..............4</td>
</tr>
<tr>
<td>ARCH-2330</td>
<td>Structures 1 ......................................4</td>
<td>Elective ..........4</td>
<td></td>
</tr>
<tr>
<td>ARCH-2130</td>
<td>Contemporary Design Approaches ................2</td>
<td>Science Sequence II 1 ................................4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Science Sequence I ................................4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
<td><strong>Credit Hours</strong></td>
</tr>
<tr>
<td>ARCH-4xxx</td>
<td>Design Studio 5 (Industrial Design) ...........4</td>
<td>ARCH-4960</td>
<td>Design Studio 6* ..................4</td>
</tr>
<tr>
<td>STSS-4800</td>
<td>Public Service Internship ........................4</td>
<td>STSS-4xxx</td>
<td>STS Advanced Option 1 ................4</td>
</tr>
<tr>
<td>ARCH-4330</td>
<td>Structures 2 .......................................4</td>
<td>ARCH-4740</td>
<td>Bldg. Sys. and Env ................4</td>
</tr>
<tr>
<td>DSES-2010</td>
<td>Statistics ..........................................4</td>
<td>ARCH-xxxx</td>
<td>Concentration Elective ........4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Credit Hours</strong></td>
<td><strong>Spring</strong></td>
<td><strong>Credit Hours</strong></td>
</tr>
<tr>
<td>ARCH-4960</td>
<td>Design Studio 7* ................................4</td>
<td>ARCH-4960</td>
<td>Capstone Design Studio with B.S. ....4</td>
</tr>
<tr>
<td>STSS-4xxx</td>
<td>STS Advanced Option 1 ............................4</td>
<td>STSS-4980</td>
<td>Final Project ..................4</td>
</tr>
<tr>
<td>ARCH-xxxx</td>
<td>Final Project .......................................2</td>
<td>Elective ........4</td>
<td></td>
</tr>
<tr>
<td>ARCH-4510</td>
<td>Construction Industry Seminar ..................2</td>
<td>Elective ........4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective ........4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The degree requires 132 credit hours.

---

1. For PDI students, IHSS-2500 can be substituted for the second STS concentration option.
2. The science sequence may be selected, with the assistance of the student's adviser, from among 1000-level introductory sequences in Biology, Chemistry, Geology, or Physics, including ERTH-1030, ERTH-1040.
4. The STS Senior Project is combined with the Capstone Design Studio to make an eight-credit capstone studio project.

**These special design studios meet jointly with ENGR-4960 Design Studios 6, 7.**
# Table of Contents

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees Offered and Associated Departments</td>
<td>131</td>
</tr>
<tr>
<td>Overview of Undergraduate Programs</td>
<td>131</td>
</tr>
<tr>
<td>Overview of Graduate Programs</td>
<td>135</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>136</td>
</tr>
<tr>
<td>Chemical and Biological Engineering</td>
<td>145</td>
</tr>
<tr>
<td>Civil and Environmental Engineering</td>
<td>152</td>
</tr>
<tr>
<td>Decision Sciences and Engineering Systems</td>
<td>164</td>
</tr>
<tr>
<td>Electrical, Computer, and Systems Engineering</td>
<td>178</td>
</tr>
<tr>
<td>Materials Science and Engineering</td>
<td>196</td>
</tr>
<tr>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
<td>202</td>
</tr>
<tr>
<td>Engineering at Hartford</td>
<td>219</td>
</tr>
<tr>
<td>Interdisciplinary Programs and Research</td>
<td>225</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>225</td>
</tr>
<tr>
<td>Product Design and Innovation</td>
<td>225</td>
</tr>
<tr>
<td>Center for Composite Materials and Structures</td>
<td>227</td>
</tr>
<tr>
<td>Center for Image Processing Research</td>
<td>228</td>
</tr>
<tr>
<td>Center for Infrastructure and Transportation Studies</td>
<td>229</td>
</tr>
<tr>
<td>Center for Multiphase Research</td>
<td>229</td>
</tr>
<tr>
<td>Center for Next Generation Video</td>
<td>230</td>
</tr>
<tr>
<td>Center for Subsurface Sensing and Imaging Systems</td>
<td>230</td>
</tr>
</tbody>
</table>
School of Engineering

Dean: William A. Baeslack, III

Associate Deans: Lester A. Gerhardt, Robert W. Messler, Jr.

Director of Core Engineering: Kevin C. Craig

School of Engineering Home Page: http://www.eng.rpi.edu

Rensselaer’s School of Engineering is committed to technological excellence in integrating research and education and in educating for career success.

Outstanding leadership in innovative and progressive education is a Rensselaer hallmark. Rensselaer is renowned for producing visionary and versatile technological leaders with a superior reputation for their global impact. Solidly endowed with the fundamentals of math, science, and engineering as well as invaluable research, communication, and entrepreneurial expertise, Rensselaer engineering graduates demonstrate an exceptional propensity for practical application of their knowledge. In addition, the inclusion of a strong humanities and social sciences component within this broad education and a full spectrum of activities, both in and out of the classroom, enhance human relations skills and generate a commitment to ethical behavior and social responsibility.

Highly cognizant of the constant evolution in the field of engineering, Rensselaer is dedicated to continually enhancing and revitalizing its curricula and facilities. Evidence of this dedication is its initiatives in such emerging fields as information technology and biotechnology. Among these are the construction of a new biotechnology and interdisciplinary research building, the ongoing attraction of leaders in these fields to our already excellent engineering faculty, and the development of expanded opportunities for research within these and other developing fields at both the graduate and undergraduate levels.

Key to promoting such new initiatives, as well as enhancing traditional disciplines, is Rensselaer’s world-class faculty, most of whom hold the highest attainable degree in their fields. In addition to being actively engaged in research and teaching, most also keep their finger on the pulse of the world through consulting or entrepreneurial endeavors.

Especially appealing to Rensselaer’s exceptional faculty and students alike are its superlative laboratories and facilities that enable them to conduct outstanding research. These include studio classrooms that, in addition to being equipped with highly advanced interactive learning tools, provide the small comfortable environment that enhances the School of Engineering’s personalized approach to teaching, maximizing student interaction among classmates and professors, and encouraging hands-on, collaborative projects.

Initiatives in mobile computing and interactive delivery are also features that distinguish Rensselaer engineering programs from those at other universities. As noted in the Educational Programs and Resources section of this catalog, the Institute mandated that all undergraduate students have laptop computers as of the fall of 2002. This mandate was issued in recognition that the entire world is moving in the direction of near constant computer access. In addition, the program supports the interactive delivery initiative, in which lectures are combined with recitation, modeling, simulation, and laboratory exercises. Unlike the traditional professor-centered straight lecture format, interactive delivery centers on the students and allows them to interact with each other as well as the instructor. Through these new programs, students experience greater freedom, are no longer tied to a desk for their computing needs, and are prepared for what they will find in the real world.

Teamwork is yet another aspect of real-world engineering that Rensselaer cultivates through both its
coursework and facilities. A prime example is the Institute’s 11,000 square-foot O.T. Swanson Multidisciplinary Design Laboratory (MDL). This distinctive, first-class facility consists of a state-of-the-art design space, rapid prototyping and fabrication space, and a system integration space for both mechanical and electrical as well as electromechanical products. Here, students work in cross-disciplinary teams on a variety of industry- and service organization-sponsored and entrepreneurial projects, all with practical and real-life applications.

Augmenting the course experience for both undergraduate and graduate students is access to numerous research centers and computing resources. These include one of the largest Class 100 clean-room facilities on an academic campus, a 100-ton-g centrifuge, a linear accelerator (LINAC), the Advanced Manufacturing Laboratories, and the student-faculty shop. Engineering students use extensive interactive workstation facilities for studies in computer-aided design, analysis, and/or manufacturing. Taught and researched in the clean-rooms are integrated circuit and materials characterization, subsonic and supersonic flow, tribology, viscoelasticity, two-phase flow, mass spectrometry, and ion physics.

Other specialized and more discipline-oriented facilities include laboratories in areas such as fluidization, heat transfer, biochemical engineering, biomedical engineering, structures, earthquake engineering, image processing, plasma dynamics, mechatronics, microelectronics, microwaves, electron optics, electrical machines, electron microscopy and materials characterization, subsonic and supersonic flow, tribology, viscoelasticity, two-phase flow, mass spectrometry, and ion physics.

Sponsoring both undergraduate and graduate research are a variety of government (federal and state) agencies as well as private industry. As a result of focusing research on topics of significant commercial interest, Rensselaer, in relation to other major university engineering programs, has one of the largest fractions of support from private industry.

Rensselaer offers research opportunities in major interdisciplinary research centers, which primarily involve School of Engineering faculty and students. Among these centers are the Center for Advanced Technology (CAT), the Center for Integrated Electronics (CIE), The Center for Nanotechnology Research, and the Scientific Computation Research Center (SCOREC). These centers are interdisciplinary, so that center projects include students from each of several curricula. For example, in the CIE, students from many departments (e.g., Physics; Materials Science and Engineering; Mechanical, Aerospace; and Nuclear Engineering; Electrical, Computer, and Systems Engineering; Chemical Engineering; and Civil and Environmental) are members of teams that conduct government- and industry-supported basic and applied research.

Projects currently under way include multilevel interconnects, chemical-mechanical polishing, polymers for interlevel dielectrics, compound semiconductors, and wireless manufacturing programs that employ flexible technologies and organizations, as well as improved communications to help solve manufacturing problems. Also world-renowned is SCOREC’s simulation-based engineering approach in which state-of-the-art computers and numerical models are applied to problems of great societal need.

In addition to the major Institute centers, the School of Engineering conducts research in its own multidisciplinary centers. These include the Center for Composite Materials and Structures, the Center for Infrastructure and Transportation Studies, the Center for Image Processing Research, and the Center for Multiphase Research. At the department level, the School offers seven additional centers: the Bioseparations Research Center, the Center for Services Research and Education, the Agile Manufacturing Research Center, the Statistical Consulting Research Center, the Center for Glass Science and Technology, the Geotechnical Centrifuge Research Center, and the Flexible Manufacturing Center.
Substantial Rensselaer research is also conducted outside these major centers, some involving multiuni-
versity collaboration. These research centers complement the following seven academic departments:
Biomedical Engineering; Chemical Engineering; Civil and Environmental Engineering; Decision Sciences
and Engineering Systems; Electrical, Computer, and Systems Engineering; Materials Science and
Engineering; and Mechanical, Aerospace, and Nuclear Engineering.

All departments offer both undergraduate and graduate curricula and degree programs in their fields.

### Degrees Offered and Associated Departments

<table>
<thead>
<tr>
<th>Degree</th>
<th>Associated Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeronautical Engineering</td>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Biomedical Engineering</td>
<td>Biomedical Engineering</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td>Computer Systems Engineering</td>
<td>Electrical, Computer Systems Engineering</td>
</tr>
<tr>
<td>Decision Sciences and Engineering Systems</td>
<td>Decision Sciences and Systems Engineering</td>
</tr>
<tr>
<td>Electric Power Engineering</td>
<td>Electrical, Computer, and Systems Engineering</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>Electrical, Computer, and Systems Engineering</td>
</tr>
<tr>
<td>Engineering Physics</td>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Environmental Engineering</td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td>Industrial and Management Engineering</td>
<td>Decision Sciences and Engineering Systems</td>
</tr>
<tr>
<td>Manufacturing Systems Engineering</td>
<td>Decision Sciences and Engineering Systems</td>
</tr>
<tr>
<td>Materials Engineering</td>
<td>Materials Science and Engineering Systems</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Mechanics</td>
<td>Mechanical Engineering, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Nuclear Engineering</td>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Nuclear Engineering and Science</td>
<td>Mechanical, Aerospace, and Nuclear Engineering</td>
</tr>
<tr>
<td>Operations Research and Statistics</td>
<td>Decision Sciences and Engineering Systems</td>
</tr>
<tr>
<td>Transportation Engineering</td>
<td>Civil and Environmental Engineering</td>
</tr>
</tbody>
</table>

### Overview of Undergraduate Programs

#### Baccalaureate Program

In general, the Bachelor of Science program is intended for students seeking careers in engineering-relat-
ed areas or as a basis for advanced study in fields other than engineering. To obtain a B.S. in an engineering
field, students must fulfill the general requirements listed in the Academic Information and Regulations
section of this catalog and satisfactorily complete the prescribed engineering curriculum. Certain cours-
es, such as one-credit-hour nonengineering courses graded on a satisfactory/unsatisfactory basis or more
than six credit hours of ROTC courses, cannot be applied toward the degree requirements. Also note-
worthy is that courses in accounting, industrial management, finance, entrepreneurship, and personnel
administration that are offered by the School of Management, as well as ROTC courses, will not satisfy
the humanities and social sciences requirement, but may be taken as free electives.

Although many students enter at the freshman level and achieve all their education objectives at
Rensselaer, a significant number find it accommodating and advantageous to enter at intermediate lev-
Entrance into the engineering program is particularly attractive to graduates of two-year colleges. All such students enter with advanced standing and credit according to their credentials.

**Professional Program**

For most students, specialization and determination of the degree program that matches their individual career goals takes place during the third year. At this point, a student may pursue either a fourth year for their Bachelor of Science (B.S.) degree in an engineering specialty or, if accepted by the Office of Graduate Education for the professional program, undertake a coherent program integrating advanced undergraduate and graduate study leading to the Master of Engineering (M.Eng.) degree in a specific field, and receiving a Bachelor of Science along the way. This professional program offers post-baccalaureate studies specifically intended as preparation for professional engineering practice. Graduates of other colleges and universities may be admitted with advanced standing (the Professional Program excepted) if they have appropriate accredited baccalaureate engineering degrees or the equivalent. Admission to a professional degree program is based on demonstration of adequate preparation and competence. The faculty in each curriculum judges qualifications for admission. Application should be made directly to the Office of Graduate Education.

**Engineering Core Curriculum**

The core engineering program forms the base for all engineering curricula. In addition to providing a solid base for later specialization, it allows students who are undecided as to their choice of engineering field or discipline an opportunity to clarify their interests. Such students can, by using the electives in the first two years, sample various disciplinary offerings to aid in choosing which engineering field to pursue.

The core engineering curriculum in the general format is presented on the following pages. Specific curricula for each field of specialization are presented under the corresponding disciplinary headings for students who are certain of their disciplinary choices and wish to begin specializing earlier than the third year. Two kinds of programs are listed under each discipline: (1) a four-year baccalaureate program leading to the Bachelor of Science degree; (2) a professional program, taken in the fourth and fifth years, leading to the B.S. and M.Eng. degrees.

While undergraduates normally are not allowed to take graduate-level courses (levels 6000–9000) except by special permission of the instructor, a student admitted to the Professional School may be required to take certain courses in the 6000–9000 range and may elect other such courses with the approval of his or her adviser.

All School of Engineering students entering Rensselaer directly from high school begin their curricula with the core engineering program. The primary objective of this program is to provide students with a liberal education and to develop a broad scientific and technical foundation for their future specialization. This predisciplinary-specific program usually extends through the second but may extend into the third academic year. During this phase, the primary focus is on the foundations of engineering as a unified field. The foundation in mathematics, physics, chemistry, and biology, combined with the specified engineering sciences (e.g., strength of materials or thermal-fluids, etc.) satisfies basic technical knowledge requirements without regard to the intended field of specialization. In the humanities and social sciences area, courses not only enrich the student as an individual but also provide the perspective professionals need to make decisions that will affect society. The course Introduction to Engineering Design is intended to enhance the student’s ability to apply knowledge resourcefully to resolve engineering problems.

The electives within the core engineering program, together with the required basic content, give each student the opportunity to refine his or her goals and develop a broad and solid foundation. Elective courses also allow undecided students to sample professionally oriented courses from several curricula so as to make a more enlightened choice of major. A student can also choose electives to provide a broader base...
or use them to focus on a particular field at an early stage. An imaginative student, with faculty counsel, can develop any number of creative study programs. It is also possible to major in one branch of engineering and obtain a concentration in a second branch.

Students need not begin specializing in a particular area until the fourth semester of study. However, when choosing electives, students must consider that each engineering discipline requires certain courses be taken earlier as field (or discipline) prerequisites.

To provide proper guidance, each student is assigned a faculty adviser who is knowledgeable in core engineering matters and can help the student plan a program to best meet his or her educational and career objectives. Once a student identifies a specific curriculum to pursue, a new adviser, who is particularly aware of the opportunities for advanced study in that area, is assigned.

The combination of the core engineering program with the subsequent discipline-specific courses provides a coherent yet flexible curriculum that allows students to obtain an engineering education at all levels in multiple focus areas. The overall School of Engineering program is structured to permit students to select plans of study that fit their individual goals, aptitudes, and interests. It also enables students to enter and leave at points most appropriate to their individual plans and to facilitate entrance at intermediate levels in the undergraduate and graduate programs.

All elements of the curricula, including both core and discipline-specific courses, are under continuous review to ensure the application of new pedagogues and teaching methods and the introduction of courses covering the latest technological and computing and analysis advances. Topics such as quality, ethics, cultural sensitivity, safety, environmental impact, and contemporary issues related to science and engineering, are constantly integrated into curricula. Additionally included in Rensselaer engineering curricula is the topic of entrepreneurship. Through these efforts, Rensselaer ensures that leadership, interpersonal communications, teamwork, problem formulation, system synthesis, critical thinking, and problem-solving skills are practiced and enhanced.

To provide a clear picture of what prospective engineering students can expect in their first two years at Rensselaer, the core engineering program proceeds as follows:

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis .......... 4</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Engineering Graphics and CAD 1 ..... 1</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .................................. 4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers .... 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .............. 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes 1, 2 or</td>
</tr>
<tr>
<td>ENGR-1310</td>
<td>Intro. to Engineering Electronics 1 ..... 1</td>
</tr>
<tr>
<td>MATH-1020</td>
<td>Calculus II ................................ 4</td>
</tr>
<tr>
<td>PHYS-1100</td>
<td>Physics I ................................... 4</td>
</tr>
<tr>
<td></td>
<td>Science Elective .......................... 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .............. 4</td>
</tr>
</tbody>
</table>

1 These required courses may be taken in either order.

2 Depending on major

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations .......... 4</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II .................................... 4</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective .................. 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .............. 4</td>
</tr>
<tr>
<td>CSCI-1190</td>
<td>Beginning C for Engineers .............. 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2040</td>
<td>Intro. to Engineering Design (with PDI) .......... 4</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective .................. 4</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective .................. 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .............. 4</td>
</tr>
</tbody>
</table>
Electives
In the core engineering curriculum, electives may be selected from, but are not limited to, the following list of suggested courses. However, in most engineering curricula, specific electives are required or recommended during the core engineering phase. Students should consult the curriculum information for their intended fields of specialization before selecting electives.

Engineering Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2090</td>
<td>Engineering Dynamics</td>
</tr>
<tr>
<td>ENGR-2250</td>
<td>Thermal and Fluids Engineering I</td>
</tr>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control</td>
</tr>
<tr>
<td>ENGR-2530</td>
<td>Strength of Materials</td>
</tr>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
<tr>
<td>ENGR-2830</td>
<td>Nuclear Phenomena for Engineering Applications</td>
</tr>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation</td>
</tr>
<tr>
<td>ENGR-4750</td>
<td>Engineering Economics and Project Management</td>
</tr>
<tr>
<td>CHME-2010</td>
<td>Material, Energy, and Entropy Balances</td>
</tr>
</tbody>
</table>

Mathematics and Science Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
</tr>
<tr>
<td>MEAE-2060</td>
<td>Aerospace Fundamentals</td>
</tr>
<tr>
<td>DSES-2210</td>
<td>Production and Cost Accounting</td>
</tr>
<tr>
<td>MATH-4800</td>
<td>Numerical Computing</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td>ENGR-1600</td>
<td>Materials Science for Engineers</td>
</tr>
<tr>
<td>CHEM-2250</td>
<td>Organic Chemistry I</td>
</tr>
</tbody>
</table>

For a complete description of all engineering courses, see the Course Description section of this catalog.

Special Undergraduate Opportunities

Undergraduate Research Experience
At Rensselaer, involving undergraduates in real-world engineering research is of paramount importance. Through the Undergraduate Research Program (URP), described in the Educational Resources and Programs section of this catalog, undergraduates work directly with faculty and/or graduate students on projects requiring critical inquiries. These studies involve exciting areas of leading-edge technological research and have the potential to result in groundbreaking discoveries. Involvement in undergraduate research can be arranged strictly for the experience, for credit, or for pay. Students apply through direct contact with faculty seeking students via Web site or campus advertisements.

Cooperative Education
Students may augment their academic course work with work experience through the Cooperative Education program. Studies and work assignments are scheduled after consultation with their curriculum adviser. Although many co-op students complete their academic program in four years, some delay graduation for a year to obtain additional work experience. Additional information on Rensselaer’s Cooperative Education Program can be found in the Student Life section of this catalog under Career Development Center.

Study Abroad/Exchange Programs
Rensselaer’s School of Engineering advocates a voluntary international experience as an ideal means to promote a broad-based engineering education, develop the “citizen engineer,” and provide undergraduate students with a global perspective. To facilitate such opportunities, the School has helped formulate and actively participates in the Global Engineering Education Exchange (Global E’) program.

Oriented primarily to undergraduate students, this program offers them the chance to spend one or two semesters at an international university or one semester at the university followed by an industrial intern-
ship in that country. Preferred timing for this experience is the junior year, and students normally apply in the fall or spring of their sophomore year.

Application involves completing forms regarding required courses or desired electives. The Institute for International Education, which administers this program, matches the student to a participating university based on that student's educational discipline requirements, cultural experience, and language background. The student continues to pay tuition at the home institution (Rensselaer) and continues to be covered by financial aid mechanisms, insurance, etc. However, the student pays room and board to the host institution. Consequently, except for travel expenses, students participating in this program should incur no additional costs.

Global E3 offers students the chance to study and learn in the native language of the host country. Such opportunities, for example, are available in France, Germany, Italy, Spain, and Austria. Additional opportunities allow students to pursue foreign study opportunities at universities where the courses are presented and taught in English. These include the Technical University of Denmark, Budapest University of Hungary, and universities in the United Kingdom, Finland, Korea, Singapore, and Japan, among others. As a result, while students may benefit from knowledge of a foreign language, it is not a requirement for participation in this program. Refresher language instruction in French and German is usually given in the summer preceding the fall semester for those who have prior language experience and will be studying in the foreign language.

Approximately 30 U.S. universities and 50 universities in the rest of the world participate in the Global E3 program. Included among these nations are: Australia, Austria, Denmark, Finland, France, Germany, Hungary, Italy, Japan, Korea, Mexico, Singapore, Spain, Sweden, and the United Kingdom. People interested in the program should contact Professor Lester A. Gerhart, Associate Dean, at (518) 276-6203 or via e-mail at gerhal@rpi.edu. The program’s Web site may be found at http://www.iie.org/pgms/global-e3.

Additional opportunities designed for the Rensselaer population in general are also available. Information on these opportunities can be found in the Educational Programs and Resources section of this catalog.

Overview of Graduate Educational Programs

In preparing students to reach the pinnacle of their expertise within their chosen profession, the School of Engineering’s graduate programs strive to:

■ Develop students’ skills for conceiving, conducting, and communicating creative thought through advanced study in the classroom and inquiry-based independent and collaborative original research.

■ Deepen students’ knowledge while refining their ability to think critically and nurturing their ability to identify new areas for expanding knowledge and transferring it to application and practice.

The School of Engineering offers four graduate degrees through which students may achieve these objectives. These include the Master of Science (M.S.), Master of Engineering (M.Eng.), Doctor of Engineering (D.Eng.), and Doctor of Philosophy (Ph.D.) degrees.

Master’s Programs

Both the M.S. and M.Eng. degree programs focus on engineering fundamentals at advanced levels, and both include significant elective opportunities that permit students to individualize their study plans. Either program provides an excellent basis for further graduate work in engineering, and neither includes a foreign language requirement.

The Master of Engineering program is designed primarily for students preparing for professional practice
and does not require a thesis. Admission is based on the student’s demonstration of adequate preparation and competence. Applications for admission should be transmitted to the Office of Graduate Education. Note that many students complete a Master of Engineering and then pursue a Ph.D.

The Master of Science program encompasses diverse educational needs and is designed primarily for students intending to obtain a Ph.D. degree. Admission requires a baccalaureate degree in an area appropriate to the individual’s proposed plan of graduate study, and could conceivably be outside the field of engineering. Those who do not have a B.S. in Engineering, however, may be required to complete some extra course work that does not qualify for graduate credit. Depending on the department in which the degree is being pursued, a thesis may be required.

**Doctoral Programs**

A doctoral student formally affiliates with the department where activities most closely relate to his or her advanced study goals. However, the range of inquiry may cut across department and school lines, so that research opportunities are extremely broad, and students can pursue highly individualized programs. There are no foreign language requirements.

The Doctor of Engineering degree is characterized by the special nature of the thesis. Thus the student, working with an adviser, proposes an engineering problem of substance and develops a solution. The student must demonstrate ability to apply scientific principles to meet engineering needs, with due regard to social and economic factors and within a reasonable time constraint. The presentation and defense of his or her conclusions before a doctoral subcommittee and guests serves as the final examination for the degree.

The Doctor of Philosophy program is the traditional degree with a thesis that involves substantial original research. The program follows the general rules of the Office of Graduate Education.

**Biomedical Engineering**

**Chair:** Robert L. Spilker

**Department Home Page:** [http://www.bme.rpi.edu/](http://www.bme.rpi.edu/)

Biomedical engineers are typically involved in research and design. They discover new knowledge that they apply to designing new engineering devices and systems for the fields of medicine and biology. Among the devices that biomedical engineering (BMED) has produced are noninvasive body imaging systems, critical-care monitoring instruments used in intensive care units, and a wide spectrum of implants, such as artificial joints, oral implants, and vascular grafts, all of which are used to replace diseased tissues. With new discoveries related to stem cells, genomics, and proteomics, BMED is becoming increasingly involved in cellular and molecular biology for basic research and design of new devices and technologies. For instance, many biomedical engineers are helping to advance the new field of tissue engineering. In this capacity, they use basic knowledge about the cellular/molecular processes of tissue regeneration to help design replacement tissues and organs. At Rensselaer, a key focus is functional tissue engineering, which encompasses the biology and engineering necessary to understand, characterize, synthesize, and shape the requisite mechanical behavior of living tissues.

Founded upon a strong engineering base, the BMED curriculum combines significant life science content with courses that bring engineering solutions to medical needs. BMED students may shape a mechanical or materials concentration to develop knowledge and skills in cell and tissue engineering or implant design.
Research Innovations and Initiatives

Cell and Tissue Engineering
Cultured mammalian cells are used to study, in vitro and at the molecular level, systems of biomedical interest. Experimental projects in progress include investigations of the mechanisms of osteoblast interactions with orthopedic/dental implant materials; structure and biochemistry of the cell/biomaterial interface; the effects of mechanical stresses on cellular function, morphology, and structure; and the development of engineered tissues to repair or replace damaged tissues. Theoretical approaches are used in modeling proliferation of anchorage-dependent, contact-inhibited cells, and in quantifying morphological responses of cells to mechanical forces.

Computational Bioengineering
The level of complexity inherent in the study of human systems such as musculoskeletal or cardiovascular systems frequently dictates the need for numerical solution methods. Rensselaer is developing and applying high-performance computational methods to the study of diarthrodial joint mechanics, cardiovascular mechanics, dental mechanics, and imaging. Projects involving the development of computational methods for bioengineering applications are done in collaboration with Rensselaer’s Scientific Computation Research Center, as well as the Center for Subsurface Sensing and Imaging Systems (CenSISS).

Orthopedic Biomechanics
In an aging individual, musculoskeletal well-being is a key factor that contributes towards quality of life. The Orthopedic Biomechanics Laboratory uses a combination of cellular and tissue-level approaches to (1) identify changes in the biological and mechanical characteristics of skeletal tissues with emphasis on aging and osteoporosis; and (2) develop microenvironments conducive to regeneration of lost or damaged matrix. Current research areas include biology and mechanics of hard tissue, cellular control of tissue growth and development, mechanobiology of skeletal tissue regeneration, and fatigue fractures of long bones.

The Bone-Implant Interface
In oral/maxillofacial surgery, orthopedic surgery, and tissue engineering, events at the bone-implant interface ultimately determine clinical implant performance. All such interfaces transmit loads, so interfacial biomechanics and biomaterials become extremely relevant. Continuing projects include (1) characterization of applied forces and moments on oral implants in vivo, and (2) assessment of bone biology at loaded versus unloaded bone-implant interfaces. New aspects of these projects include digital image-based strain analysis of interfaces and cellular/molecular-level approaches to understand interfacial bone healing and remodeling under the influence of interfacial biomechanics and biomaterials.

Other Research
Biomedical engineering research at Rensselaer involves three schools within the Institute and interactions with Albany Medical College, the University of Pennsylvania, Columbia University, Université de Montréal, UC San Francisco, Center for Tissue Integrated Prostheses (Spokane, Wash.), and several other hospitals.
Faculty*

Professors
Bizios, R.—Ph.D. (Massachusetts Institute of Technology); cellular bioengineering, cell/biomaterial interactions, biomaterials.
Brunski, J.B.—Ph.D. (University of Pennsylvania); dental biomechanics and implants, bone healing at interfaces, biomaterials.
Newell, J.C.—Ph.D. (Albany Medical College); cardiopulmonary physiology, systems modeling, impedance imaging.
Roysam, B.—D.Sc. (Washington University); electrical, computer, and systems engineering; intelligent imaging at low SNR; parallel computation; biomedical applications.
Spilker, R.L.—Sc.D. (Massachusetts Institute of Technology); computational mechanics and biomechanics (department chair).
VonMaltzahn, W.W.—Ph.D. (University of Hannover, Germany) bioinstrumentation, physiological measurements and modeling.

Associate Professors
DePaola, N.—Ph.D. (MIT-Harvard Medical School); biofluid mechanics, cellular bioengineering.
Xu, G.X.—Ph.D. (Texas A&M University); environmental health physics, health and medical physics, Monte Carlo simulations, anatomical modeling, biomedical use of radiation.

Assistant Professors
Stegemann, J.P.—Ph.D. (Georgia Institute of Technology); cell and tissue engineering, vascular biology extracellular matrix biology.
Plopper, G.—Ph.D. (Harvard University Medical School); extracellular matrix and tissue engineering.
Vashishth, D.—Ph.D. (University of London, UK); orthopedics biomechanics, hard tissue biology (aging and osteoporosis), sports medicine (stress fractures and running injuries), skeletal tissue regeneration.

Affiliated Faculty
Cheney, M.—Ph.D. (Indiana University); professor of mathematical sciences; applied mathematics, differential equations, mathematical computed tomography.
Doremus, R.D.—Ph.D. (University of Illinois, University of Cambridge); professor of glass and ceramics science; physical chemistry, solutions of polyelectrolytes and proteins.
Isaacson, D.—Ph.D. (New York University); professor of mathematics and computer science; electric current computed tomography.
Savic, M.—Eng.D.Sc. (University of Belgrade); professor of electrical, computer, and systems engineering; controlled cryodestruction, signal processing.

Adjunct Faculty
Bowser, S.S., Jr.—Ph.D. (University of Albany, SUNY); cell structure and function, particularly cell motility and cytoskeleton-membrane interactions, effects of mechanical forces on cell physiology, biology of benthic foraminifera.
Cousins, J.R.—Ph.D. (Johns Hopkins University); magnetic resonance imaging and spectroscopy.
Del Vecchio, P.J.—Ph.D. (Fordham University); biology, vascular endothelium.
Edic, P.M.—Ph.D. (Rensselaer Polytechnic Institute); electrical impedance imaging and magnetic resonance imaging computation.
Feustel, P.—Ph.D. (Albany Medical College); cerebral circulation and respiration regulation.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Flaherty, L.—Ph.D. (Cornell University Medical College); molecular genetics; mammalian genetics. Director, Genomics Institute, Wadsworth Center of the NYS Dept. of Health.

Jacobs, R.L.—M.D. (State University of Iowa); orthopedics, physiology, bone biochemistry.

Lee, B.Y.—M.D. (Seoul National University School of Medicine); surgical research, peripheral vascular surgery.

Metsger, D.—Ph.D. (University of Illinois at Chicago); regulation of immunity, mucosal immunology, immune response to xenogenaic tissue implants.

Minnear, F.—Ph.D. (Oregon Health Sciences University) Professor, The Center for Cardiovascular Sciences, Albany Medical Center; regulation of endothelial barrier function.

Rizzo, V.—Ph.D. (New York Medical School) Assistant Professor, The Center for Cardiovascular Sciences, Albany Medical College. Mechano-chemical signaling in endothelial cell canaeole.

Rangert, B.—Ph.D. (Chalmers Institute of Technology); dental implants, biomaterials, biomechanics.

Singer, H.—Ph.D. (University of Virginia); vascular smooth muscle cell biology, calcium/calmodulin-dependent protein kinases, intracellular regulation of smooth muscle contractility.

Turner, J.N.—Ph.D. (State University of New York, Buffalo); biophysics, anatomic pathology, quantitative light microscopy.

Emeritus Faculty

Ostrander, L.E.—Ph.D. (University of Rochester); information processing, biomedical signal analysis, human factors in medical equipment design.


Zelman, A.—Ph.D. (University of California, Berkeley); membrane transport phenomena, food processing.

Undergraduate Programs

Objectives of the Undergraduate Curriculum

The Biomedical Engineering Department’s baccalaureate program will:

- Provide students with a solid foundation in mathematics and computation and in the biological and physical sciences.
- Train students in the application of the engineering problem-solving skills of analysis, modeling, and simulation to current problems in medicine and biology.
- Train students in engineering design of biomedical products, processes, and systems.
- Provide students with specialized technical expertise to prepare for industrial, academic, or other careers in biomedical engineering.
- Develop students with strong written and oral presentation skills, as well as the ability to lead and contribute to multidisciplinary teams in industrial, academic, and clinical environments.
- Provide students with a broad learning experience, including the study of the humanities and social sciences, with an emphasis on ethics and social responsibility.
- Prepare students for life-long learning using interactive studio environments and modern learning cycle strategies.

Students may achieve these objectives through completion of either the baccalaureate program leading to the B.S. degree or the professional program leading to the M.Eng. degree. Both programs are described in detail below. However, to ensure selection of the appropriate concentration and courses to meet individual interests and goals, students should consult their academic adviser as early as possible.
# Baccalaureate Program

In lieu of the general core engineering program presented earlier, students who identify biomedical engineering as their discipline may follow the program outlined below. This curriculum requires a minimum of 126 credit hours.

## First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ENGR-1100 Intro. to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-1300 Chemistry Principles for Engineers</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-1010 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ENGR-1330 Intro. to BME 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ENGR-1200 Engineering Graphics and CAD</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ENGR-1600 Materials Science for Engineers 3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-1100 Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2</td>
<td>4</td>
</tr>
</tbody>
</table>

## Second Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>ENGR-2050 Intro. to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-2400 Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>BMED-2200 Dynamic Systems for Biomedical Engineering</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration I 4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2</td>
<td>4</td>
</tr>
</tbody>
</table>

## Third Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>BIOL-4290 Human Physiological Systems</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration II 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration III 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration IV 5</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>ENGR-2600 Modeling Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>BMED-4500 Advanced Systems Physiology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration V 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Concentration VI 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Professional Development II 7</td>
<td>2</td>
</tr>
</tbody>
</table>

## Fourth Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>BMED-4010 Biomedical Engineering Lab</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 2</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective I 6</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Free Elective II 6</td>
<td>3–4</td>
</tr>
<tr>
<td>Spring</td>
<td>BMED-4600 BME Design 8</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>BMED-4600 Concentration VII 5</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective III 6</td>
<td>3–4</td>
</tr>
<tr>
<td></td>
<td>Free Elective IV 6</td>
<td>3–4</td>
</tr>
<tr>
<td></td>
<td>ENGR-4010 Professional Development III 8</td>
<td>1</td>
</tr>
</tbody>
</table>

---

1 ENGR-1330 or ENGR-1310 or ENGR-1300 may be taken in the first or second year.

2 Placement of humanities and social science electives can be varied with free electives. The courses counted as free electives must show a minimum of 12 credit hours. The total credit hours for the degree is 126–128.

3 Science requirement.

4 For both the materials/mechanics concentrations, choose ENGR-2250.

5 BMED specified concentration courses (see listing p. 156). Check prerequisites to assure that courses are taken in appropriate order. Free electives may be moved to different semesters to accommodate timing of concentration courses.

6 The minimum total credit hours of free electives is 12, with no restrictions on the included number of 3 and 4 credit hour courses.

7 Professional Development II will be fulfilled from a published list at the start of each semester and can be taken either semester; Professional Development III can be taken either semester of the senior year. Professional Development I is part of ENGR-2050.

8 Capstone and writing-intensive course.
Concentrations

Biomedical Engineering offers two concentrations. Students interested in implant design, cell and tissue engineering, and computational biomechanics, for instance, may select a materials or mechanics concentration. For additional concentration courses, consult a department adviser. Course selections from these concentrations are given below and the typical sequence is designated by S2 for spring 2nd year; F3 for Fall 3rd year, etc.

**Materials Emphasis**

- ENGR-2250 Thermal and Fluid Engineering I (S2)
- MTL-4100 Thermodynamics of Materials (F3)
- MTL-4030 Introduction to Glass Science (F3) or MTLE-4050 Introduction to Polymers (F3)
- BMED-4540 Biomechanics (F3)
- BMED-4240 Tissue-Biomaterial Interactions (S3)
- MTL-2100 Structure of Engineering Materials (S3)
- MTL-4250 Properties of Engineering Materials II (S4)

**Mechanics Emphasis**

- ENGR-2090 Engineering Dynamics (F3)
- ENGR-2250 Thermal and Fluids Engineering I (S2)
- ENGR-2530 Strength of Materials (F3)
- BMED-4540 Biomechanics (F3)
- BMED-4240 Tissue-Biomaterial Interactions (S3)
- MANE-4240 Introduction to Finite Elements (Fall)
- MANE-4030 Elements of Mechanical Design (S4) or ENGR-2350 Embedded Control (S4) or MANE-4610 Vibrations (S4)

**Humanities and Social Sciences Electives**

In this area, electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences, through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in humanities or social sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Minor Programs**

The Department of Biomedical Engineering offers a minor in biomedical engineering for undergraduates majoring in other engineering and science fields. The selection of courses must have the prior approval of the department and must form a coherent program. Below is a list of suggested courses for a minor in biomedical engineering.

**For Mechanical or Materials Engineering Majors**

- BMED-4010 Biomedical Engineering Laboratory
- BIOL-4290 Human Physiology Systems
- BMED-4500 Advanced Systems Physiology
- BMED-4540 Biomechanics
- BMED-4240 Tissue-Biomaterial Interactions
Graduate Programs

The department offers programs leading to M.Eng., M.S., D.Eng., and Ph.D. degrees. Persons seeking admission to any of these graduate degree programs in biomedical engineering should have their Graduate Record Examination (GRE) aptitude test scores sent to Graduate Admissions Office. Applicants who cannot take the test should attach an explanation to the application. Submission of the GRE advanced test scores is also recommended. For further information on the GREs, write to Graduate Record Examinations, Box 955, Princeton, NJ 08541.

Master’s Programs

Rensselaer requires completion of at least 30 credit hours (with satisfactory grades) beyond the bachelor’s degree. At least 15 of these credit hours must have suffix numbers 6000–6990.

Master of Science

The Biomedical Engineering M.S. degree can be obtained with or without a thesis. The latter option is recommended for students who do not plan further graduate studies. The thesis option is advised for students who plan to obtain a higher graduate degree. The master’s thesis should contribute new knowledge to the field of study.

Students pursuing either M.S. option must complete a minimum of 30 credits. In consultation with the adviser, they must develop a plan of study that satisfactorily meets Institute requirements, core concentration requirements, and recommended technical electives. For students completing a thesis, at least 24 credits must be met in these requirements, and a maximum of six credits may be earned by thesis work.

Master of Engineering

This option is recommended for students interested in industrial positions. The M.Eng. requires completion of a minimum of 30 credits. Students pursuing this option must also develop a plan of study with their adviser which includes at least 24 credits, that satisfactorily meet Institute requirements, core concentration requirements, and recommended technical electives. Although a project is not required, an applied research, development, or design project may be completed, with the academic adviser’s approval, for a maximum of six credits. The project should represent the solution of a significant engineering problem.

Concentrations

At the M.Eng. and M.S. level in Biomedical Engineering, programs of study fall into three different concentration areas:

Biomedical Instrumentation

Bioinstrumentation, systems modeling, and computer technology and techniques have been the basis for some of the most advanced and intensive achievements in biomedical engineering. Students in this concentration prepare to work in the design and construction of transducers and electronic processing equipment for online measurements of physiological parameters. Techniques for computer simulation and pattern recognition, are additional aspects of advanced training in this concentration. There are active research programs in electrical impedance imaging, and image processing that cover the theoretical basis and practical applications of noninvasive internal imaging of animate and inanimate objects.

Biomaterials

Engineering applications for the design of prosthetic devices such as implants or tissue-engineered constructs require sophisticated knowledge of the structure, properties, and behavior of a wide range of mate-
rial—metals, ceramics, glasses, polymers, composites, and biological materials. Implant design and the
new field of tissue engineering involve a working knowledge of material properties, tissue-biomaterial
interactions, and biocompatibility.

**Biomechanics**
Mechanics has helped solve problems involving cell physiology, blood flow, skin rheology, bone mechan-
ics, load-bearing prostheses design, joint lubrication methods, and countless other items of interest in med-
icine. Continuum mechanics, finite element analysis, strain gauge techniques, model analysis techniques,
and micromechanics are some of the methods used to attack these problems in biomechanics.

**Biomedical Engineering Requirements**
In addition to the Biomedical Engineering core requirements, students must also meet the concentration
and elective requirements.

**Core Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED-4010</td>
<td>Biomedical Engineering Lab 1</td>
</tr>
<tr>
<td>BMED-4500</td>
<td>Advanced Systems Physiology*</td>
</tr>
</tbody>
</table>

**Biomaterial Concentration requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6020</td>
<td>Design of Experiments (or an equivalent course)</td>
</tr>
</tbody>
</table>

**Biomechanics Concentration requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMED-4540</td>
<td>Biomechanics</td>
</tr>
<tr>
<td>DSES-6020</td>
<td>Design of Experiments (or an equivalent course)</td>
</tr>
</tbody>
</table>

*New graduate students entering BMED with no previous biological course work can take BMED-4290 as a background course, but in this case,
this course is not counted in the credits for the master’s or Ph.D. degree.*
Recommended technical electives for a BMED Biomaterials Concentration

BMED-6240  Tissue-Implant Interfaces
BMED-6280  Biomechanics of Soft Tissues
BMED-6290  Biomechanics of Hard Tissues
BMED-6500  Mechanobiology
MTLE-6080  Electron Microscopy of Materials
MTLE-6150  Fracture of Solids
BMED-6280  Biomechanics of Soft Tissues

Recommended technical electives for BMED Biomechanics Concentration

BMED-6240  Tissue-Implant Interfaces
BMED-6280  Biomechanics of Soft Tissues
BMED-6290  Biomechanics of Hard Tissues
BMED-6500  Mechanobiology
MANE-4240  Introduction to Finite Elements
MANE-6660  Fundamentals of Finite Elements
MTLE-6150  Fracture of Solids
MTLE-6830  Deformation of Materials and Rheology

Doctoral Programs

Matriculation into the doctoral program is based upon prior demonstration of a high level of academic achievement in graduate and/or undergraduate work. Advanced study and research are conducted under the guidance of a faculty member of the Department of Biomedical Engineering and an interdisciplinary committee. Usually 54 credits of formal courses are required in addition to the residency and thesis requirements. These requirements are formalized in a plan of study that is prepared in consultation with the research adviser and doctoral committee.

Course Descriptions

Courses directly related to all Biomedical Engineering curricula are described in the Course Description section of this catalog under the department codes BMED, CHME, ECSE, MTLE, and MANE.
The chemical conversion of resources into new, more useful forms has been the traditional concern of chemical engineers. In recent years, a critical concern with the depletion of resources has developed, leading to increased efforts to conserve, recycle, and find alternatives. Concurrently, with high-technology advances in biochemical and semiconductor processing, these developments pose challenges that fall on the chemical engineering profession.

The major educational objective in the Howard P. Isermann Department of Chemical Engineering is to prepare students to enter their engineering practice dealing with chemical as well as physical processes to meet the challenges of the future. The chemical engineering curriculum, which builds on chemistry, mathematics, basic sciences, and engineering science, culminates in professional applications in which theory is tempered by engineering art and economic principles. Through this curriculum, graduates are prepared equally well for professional practice or for advanced study.

Opportunities for creative and satisfying practice in chemical engineering can be found in conception, design, control, or management of processes involving chemical change. These processes range from the more conventional conversion of crude oil into petrochemicals and plastics, to the microbiological transformation of hardwood chips into specialty alcohols, or to the creation of semiconductor devices from silicon wafers. Diverse career choices exist not only in the chemical industry, but in virtually all processing industries, including agricultural, biochemical, chemical, food, nuclear, semiconductor processing, and environmental operations. By avoiding specialization and emphasizing basic principles, the program prepares its graduates for positions spanning the spectrum of activities from research and development, to process and project engineering, to production, or to technical marketing.

### Research and Innovation Initiatives

#### Fluid Mechanics
Projects in this area involve the mechanics of fluidized beds, spouted beds, bubbles, low Reynolds number hydrodynamics, kinetic theory, two-phase flow, and surfactant behavior in organic-aqueous systems.

#### Heat Transfer
Topics of interest include free convection stability, forced convection (particularly in laminar flow systems), fluid-to-particle heat transfer in fluidized and spouted beds, and boiling. Studies on heat and mass transfer at interfaces are also under way.

#### Mass Transport
Research is in progress on simultaneous heat and mass transfer in porous media; the effects of interfacial phenomena on mass transfer; diffusion and mixing in laminar flow systems; transient dispersion processes in capillaries, porous media and open channels; and crystal growth phenomena.

#### Thermodynamics
Activities include molecular simulation, the analysis and correlation of phase-equilibrium data, the development and evaluation of fluid-phase equations of state, and the study of topics in solution thermodynamics.
Air Resources
Research activities include field and modeling investigations directed toward the understanding of the acid rain phenomenon, fundamental studies of the experimental and theoretical adsorption with chemical reaction of trace gases into moving drops, and improved understanding of liquid phase reaction mechanisms. The development of improved incineration of hazardous wastes requires basic understanding of the time-temperature history of combustion gases. Experimental investigations into the combustion of simulated chlorinated wastes are also in progress.

Interfacial Phenomena
Problems under investigation include interfacial resistance to mass transfer and the interaction between surface forces and interfacial convection. Work in the interfacial area is concerned with heat, mass, and momentum transfer in multicomponent, ultrathin, liquid films. Research includes studies on condensation and evaporation in the contact line region, distillation from ultrathin films, lubrication, surface-tension-driven instabilities in atomically clean liquid metals, pattern formation in dendritic growth, protein-solid interaction, and the design of biocompatible surfaces.

Biochemical and Biomedical Engineering
Research projects in biochemical engineering emphasize biocatalysis, bioseparations, and metabolic engineering. Fundamental and applied aspects of enzyme technology, mammalian cell culture, membrane sorption and separation, displacement chromatography, and salt-induced precipitation are important areas of focus. New designs involving aqueous and nonaqueous enzyme technology are being developed, as are new types of membrane-entrapped-enzyme and animal-cell-suspension reactors, which are being built, tested, and analyzed. Metabolic engineering processes are being used to develop high-rate bacterial fermentations and overproducing hybridoma cultures for producing chemical intermediates and monoclonal antibodies, respectively. Control theory of biological processes and an optical biosensor for metal detection are also being pursued. Projects in biomedical engineering involve the design of polymeric inhibitors of bacterial toxins and viruses, and the use of microfabrication tools to modulate the interaction of mammalian cells with their environment for applications in tissue engineering.

Separation Processes
The fundamentals of separating species, especially in dilute solutions, is the focus of ongoing experimental and theoretical research. Projects include the understanding of separation by membranes and the development of new membranes, adsorption and chromatographic separations for preparing laboratory quantities of unusual chemicals, and protein precipitation processes. Another major research program is the recycling of microelectronic etching solutions using membrane separation processes.

Molecular Simulations
Monte Carlo and molecular dynamics simulations are being used in combination with statistical mechanical theories to understand thermodynamics, structure, and kinetics of biomolecules in aqueous solutions. Special emphasis is placed on understanding and relating water structure near different solutes and in different environments to resulting interactions (e.g., hydrophilic and hydrophobic interactions). Molecular simulation techniques are also being applied to polymeric systems to understand penetrant solubility and diffusivity in polymers.

Polymers
A large polymer research program focuses on polymer reaction engineering including devolatilization and heat transfer. Current work emphasizes bulk polymerizations in tubular reactors and segregation phenomena in stirred tank reactors. Under study are ways of enhancing heat transfer to fluids in laminar flow and the application of polymer devolatilization technology to unconventional substances. The recovery
of commingled scrap plastics by selective dissolution is a major activity. Other active areas include structure-property relationships, rheology, extrusion, and a large interdisciplinary program on biocatalysis in polymer synthesis and modification.

High-Temperature Kinetics
The development of more efficient, less polluting, combustion systems, requires accurate chemical kinetic input data on individual reactions over large temperature ranges. Rensselaer is pioneering the development of experimental techniques for obtaining such data. This work includes design, construction, experimentation, and the generation of data for use by reaction system modelers. Both fast-flow thermal and pseudostatic photochemical systems are used. Various light sources, such as lasers, combined with electro-optical detection techniques are employed to determine the time history of reactants. Larger reactants and products are observed mass spectrometrically. Microcomputers are used for experimental control and data handling. In some work, the light-emitting and electrical-charge generation aspects of reactions are also investigated. In addition to combustion, this work is important to technological fields, such as semiconductor processing, metals refining, and optical fiber and carbon black manufacturing, as well as models of the atmosphere. A better understanding of the temperature dependence of reaction rate coefficients is a significant result of this work.

Advanced Materials
Research interests are centered on developing and understanding the phenomena involved in producing advanced materials for the optical, electronic, and allied industries. Thermodynamic, transport, and chemical processes governing the formation and subsequent behavior of these materials are under active investigation. Research areas include modeling and optimizing CVD-reactor-system designs for producing high-efficiency, epitaxial layers economically in an environment sound manner, and developing nonlinear and electro-optic inorganic and organic materials for switching and memory applications. Additional research areas are understanding phenomena involved in the production and use of microlens arrays, wave-guide lasers, and determining the composition, property, and structure relationships of crystalline and glassy materials.

Process Control and Design
A major focus of this research is the development of realistic, robust control strategies for multivariable chemical processes having parameter and process uncertainties. Such strategies are created to exploit the dynamic properties inherent in the systems. Integration of the modeling, design, and control of specialty chemical and pharmaceutical processes is of particular interest.

Interdepartmental Research
Several research areas involve participation and cooperation with other departments. Such areas include polymer studies with the Materials Science and Engineering and Chemistry Departments, fermentation and other biochemical research with the Biology Department, studies in fluid mechanics with the Mathematics Department, polymer membrane fabrication with the Chemistry Department, and research on lubrication and other interfacial phenomena with the Mechanical Engineering Department. Research into state-of-the-art design and optimization of CVD reactors for semiconductor production is conducted jointly with the Center for Integrated Electronics. Additional information on research in these areas is found in the catalog sections for those departments.

Research Related Facilities
The department maintains extensive research and instructional laboratories which house myriad special and unique equipment developed for specific studies, as well as extensive analytical and optical instrumentation, minicomputers, and microcomputers. Major instrumentation such as a GC/mass spectrome-
ter, an X-ray fluorescence analyzer, an ion chromatograph, HPLC systems, and a laser zee particle char-
terization system make Rensselaer’s laboratories one of the most comprehensively equipped university
centers for research in the areas described above. The Howard Isermann Biochemical Engineering
Laboratory was established in the department exclusively for conducting biochemical engineering research.
The department research programs also use a number of major university facilities including the electron
optics laboratory and the polymer laboratories in the Materials Research Center.

**Faculty***

**Professors**

**Belfort, G.**—Ph.D. (University of California, Irvine); membrane sorption and separations engineering,
bioanalytical, biosensors, magnetic resonance flow imaging.

**Bequette, B.W.**—Ph.D. (University of Texas, Austin); chemical process modeling, control, and optimi-
mization; biomedical and drug infusion systems.

**Bizios, R.**—Ph.D. (Massachusetts Institute of Technology); cellular bioengineering, cell/biomaterial
interactions, biomaterials.

**Cale, T.S.**—Ph.D. (University of Houston); microelectronic materials processing and simulation.

**Cramer, S.M.**—Ph.D. (Yale University); biochemical engineering, chromatographic separations.

**Dordick, J.S.**—Ph.D. (Massachusetts Institute of Technology); biochemical engineering, enzyme tech-
nology, polymer chemistry, bioseparations.

**Glicksman, M.E.**—Ph.D. (Rensselaer Polytechnic Institute); transport phenomena of crystal growth.

**Kumar, S.K.**—Ph.D. (MIT) Synthetic and bio-polymers, nano composites and nanomaterials.

**Lahey, R.T., Jr.**—Ph.D. (Stanford University); two-phase flow and boiling heat transfer.

**Nauman, E.B.**—Ph.D. (University of Leeds, England); reaction engineering, dispersion theory, lami-
nar heat transfer.

**Associate Professors**

**Plawsky, J.L.**—Sc.D. (Massachusetts Institute of Technology); optical, nonlinear and electrooptic,
crystalline, and glassy materials.

**Assistant Professors**

**Garde, S.S.**—Ph.D. (University of Delaware); molecular simulation.

**Kane, R.S.**—Ph.D. (Massachusetts Institute of Technology); biomedical engineering, polymers, sur-
faces, nanomaterials.

**Martin, L.L.**—Ph.D. (University of California, Los Angelas) process systems engineering, design for
waste minimization and pollution prevention.

**Sharfstein, S.T.**—Ph.D. (University of California, Berkeley); biochemical engineering, mammalian
cell culture.

**Distinguished Research Professors**

**Fontijn, A.**—D.Sc. (University of Amsterdam, Netherlands); combustion, high-temperature kinetics,
gas phase reactions, atmospheric chemistry.

**Gill, W.N.**—P.E. Ph.D. (Syracuse University); transient dispersion processes, reverse osmosis systems,
crystal growth phenomena, surface-tension-driven flow.

**Wayner, P.C., Jr.**—Ph.D. (Northwestern University); heat transfer, interfacial phenomena.

**Adjunct Faculty**

**Belfort, M.**—Ph.D. (University of California, Irvine); molecular biology.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions,
including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees
meeting.
Emeritus Professors
Abbott, M.M.—Ph.D. (Rensselaer Polytechnic Institute); thermodynamics.
Altwicker, E.R.—Ph.D. (Ohio State University); air pollution control, atmospheric chemistry.
Bungay, H.R., III—PE, Ph.D. (Syracuse University); water resources, biochemical engineering.
Chung, C.I.—Ph.D. (Rutgers University); polymer processing, polymer melt rheology, relaxation behavior in polymer solids.
Littman, H.—Ph.D. (Yale University); fluidization, fluid-particle systems.
Muckenfuss, C.—Ph.D. (University of Wisconsin); kinetic theory, transport phenomena.
Van Ness, H.C.—PE, D.Eng. (Yale University); thermodynamics.

Undergraduate Programs
Objectives of the Undergraduate Curriculum
Graduates of the Howard P. Isermann Department of Chemical Engineering will:
■ Have a solid background in chemistry, mathematics, basic science and engineering science
■ Have technical knowledge of fundamental chemical engineering concepts of balance equations, thermodynamics, transport phenomena, chemical reaction engineering, separations processes, and process systems engineering
■ Be able to communicate technical material through written reports and oral presentations
■ Apply chemical engineering principles and economic analysis to the synthesis of chemical processes and products. These complex problems require teamwork, and the ability of individuals to serve as leaders and contributors
■ Be prepared equally for professional practice or further graduate study in chemical engineering and biological engineering.
■ As with all engineering disciplines, be informed citizens, broadly educated in the humanities and social sciences.

Students may achieve these objectives through completion of either the baccalaureate program leading to the B.S. degree or the professional program leading to the M.Eng. degree. Both programs are described in detail below.

Baccalaureate Programs
The chemical engineering program comprises a minimum of 37 courses, which include three free electives and three area electives: one in advanced chemistry, one in advanced chemical engineering, and one in a nonchemical engineering area. On completion of three years of the baccalaureate program, the student may continue to the fourth year or be admitted to the professional program. While individual variations may be made in the course sequence in consultation with a faculty adviser, all listed courses and elective credits in the curricula must be satisfactorily completed to qualify for the specified degrees. A program outline that indicates required courses and electives is provided below. The complete curriculum totals 128 credit hours.

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis .............4</td>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD ¹ ................................1</td>
</tr>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes 12 ........................1</td>
<td>ENGR-1600</td>
<td>Materials Science for Engineers ........................4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers .........4</td>
<td>MATH-1020</td>
<td>Calculus II .................................4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ........................................4</td>
<td>PHYS-1100</td>
<td>Physics I .................................4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .....................4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective .....................4</td>
</tr>
</tbody>
</table>

¹ These required courses may be taken in either order.
² May be replaced by ENGR-1310.
Electives

As is evident in the above outline, the B.S. program includes several types of electives, three of which are specifically designated. These designated electives are subject to the following constraints:

- The chemistry elective must be in advanced chemistry or in an advanced chemistry-related subject. The Bioorganic Mechanisms and Molecular Biochemistry courses are particularly recommended.
- The chemical engineering elective must be in chemical engineering or in an approved, advanced chemical engineering subject.
- The engineering elective cannot be a chemical engineering course; it must be at least 2000-level and contain four credits of engineering topics.

The curriculum clearance officer, who maintains a list of appropriate courses, must approve selection of these three constrained electives. The three free electives are completely unconstrained.

Humanities and Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

---

1 Includes Professional Development I.

2 This course will be fulfilled from a list published at the start of each semester. It may be taken either semester in Year 3.

3 May be taken either semester in Year 4.
Professional Program
Students who, at the end of their third year, apply and are accepted to this program will complete ten additional courses beyond the baccalaureate degree and will be awarded the M.Eng. degree. This program is described in detail below.

Graduate Programs
The Chemical Engineering Department offers the Master of Science, the Master of Engineering, and the Doctor of Philosophy degrees, each of which is tailored to fulfill the varying educational needs of its graduate students.

All graduate programs offer flexibility. Students are advised to plan programs that use course choices and electives to obtain in-depth studies in one or more subspecialties of their degree majors. Cross-disciplinary studies using courses offered by other departments or schools at Rensselaer are encouraged.

In addition, all graduate degree programs are arranged individually, and students are encouraged to use electives to conduct intensive studies in one or more subdisciplines or specialties. The M.S. and Ph.D. programs are particularly flexible. However, each student's program must include the following courses:

CHME-6570 Chemical and Phase Equilibria (Fall)
CHME-6610 Mathematical Methods in Chemical Engineering I (Fall)
CHME-6510 Advanced Fluid Mechanics I (Spring)
CHME-6640 Advanced Chemical Reactor Design (Spring)

Master's Programs
The master's degree represents an intermediate level of academic preparation. It is often the optimal degree for careers in engineering design.

Master of Science
The M.S., which requires a thesis, may be used for professional entry, but is also well suited to students who wish to measure their ability to get a Ph.D. without commitment of extra time beyond that required for an M.S. A special optional master's program is available for this purpose.

For the M.S., 30 credits of graduate-level studies, including six credits for the thesis, are normally required. However, the thesis requirement may vary from three to nine hours at the discretion of the department. The 24 hours of approved course work must include at least 15 credits of 6000-level courses. A formal thesis defense is not required.

Students who wish to follow the optional master's program should plan to take the Ph.D. comprehensive examination during their second semester of full-time graduate studies. The examination may be taken a maximum of two times. Passing students may register for an additional three credits of CHME-6990 Master's Thesis, and formal course work requirements for the master's degree are reduced to 21 hours. The student also has the option of proceeding directly toward a Ph.D. without completing the master's thesis. This option will normally reduce the time required for a Ph.D. by about six months. Students who elect to proceed in this manner will receive an M.S. degree, with thesis requirements waived, after two years of satisfactory full-time study and acceptance of the dissertation proposal.

Master of Engineering
The M.Eng. degree involves formal course work only and does not require a thesis. This degree is awarded on completion of 30 credits of course work. For a student with an accredited B.S. degree in chemical engineering, the program includes the following:
Credit hours

CHME-6510  Advanced Fluid Mechanics I .................................................................3
CHME-6570  Chemical and Phase Equilibria .............................................................3
CHME-6640  Advanced Chemical Reactor Design ..................................................3
Electives ..................................................................................................................18

Of the electives, at least two must be chemical engineering courses, and at least two must be nonchemical engineering courses. A feature of this M.Eng. program is the opportunity to concentrate in one of the subspecialties of chemical engineering. These areas include (but are not limited to) bioseparations, environmental engineering, materials engineering, and polymer engineering.

Doctoral Programs

The Ph.D. degree represents the highest level of academic preparation. With it, a student can expect to maintain technical competence and contributions throughout a professional career. It is usually the preferred degree for research and development in industry and government and for teaching.

Within the Chemical Engineering Department, 90 credits of graduate-level studies, including the dissertation, are required for a Ph.D. The emphasis is on advanced study in a specialty with major focus on the dissertation. A doctoral student must pass a comprehensive examination, prepare a dissertation proposal and the dissertation itself, and present and defend the dissertation.

Course Descriptions

Courses directly related to all Chemical Engineering curricula are described in the Course Description section of this catalog under the department code CHME.

Civil and Environmental Engineering

Chair: George F. List

Coordinator of Undergraduate Studies (Civil and Environmental Programs): Simeon Komisar
Coordinator of Graduate Studies (Civil Program): Jacob Fish
Coordinator of Graduate Studies (Environmental Program): James (Chip) Kilduff

Department Home Page: http://www.cee.rpi.edu

Civil and environmental engineers are responsible for providing the world’s constructed facilities and the infrastructure on which modern civilization depends. These facilities can be large and complex and require that the engineer be broadly trained and able to deal with the latest technologies.

Civil and environmental engineers focus on the analysis, design, construction, maintenance, and operation of large-scale physical systems. To ensure the proper construction and care of these complex systems and environments, Rensselaer civil and environmental engineers develop a full range of skills in design, analysis, fabrication, communication, management, and teamwork. The current rebuilding of the world’s roads, bridges, water and sewer systems, and other physical facilities has heightened society’s awareness of the profession and given it significant prominence. The growing panoply of sensors, instrumentation, intelligent facilities, and new materials is also highlighting the high-tech character of the discipline, creating new educational challenges and redefining the skill set that civil and environmental engineers need to succeed.
At Rensselaer, civil engineering has a long and distinguished history. In 1835, the Institute became the first U.S. school to issue a civil engineering degree. Among its graduates are William Gurley (1839) and Lewis E. Gurley (1845) partners in W&LE Gurley, Troy, N.Y., one of the first manufacturers of precision surveying instruments. Other world-renowned Rensselaer civil engineering graduates include:

- Francis Collingwood, Jr. (1855), honored by civil engineering’s Collingwood Prize
- Washington Roebling (1857), builder of the Brooklyn Bridge
- Seijiro Hirai (1878), a president of the Imperial Railways, Japan
- George Ferris (1881), designer of the Ferris wheel
- Milton Brumer (1923), construction manager for the Verrazano Narrows Bridge
- Werner Ammann (1928), former partner, Ammann and Whitney
- Clay Bedford, Sr. (1925), general supervisor of the construction of the Bonneville and Grand Coulee Dams
- Ralph Peck (1934), co-author with Karl Terzaghi of the internationally-known book *Soil Mechanics in Engineering Practice*

Today, Rensselaer civil and environmental engineers continue to be found at all levels in both private and public sectors throughout the world.

A long-standing tradition at Rensselaer is educational programs in environmental problem solving. An early contribution to this field was the water analysis work of William Pitt Mason (1874), the pioneer of such activities in the U.S. in the late 1800s. Edward J. Kilcawley, a Rensselaer civil engineering professor who introduced environmental engineering as an option in the mid-1940s and as degree program in the mid-1950s, contributed visionary environmental engineering concepts.

In addition to those in the Department of Civil and Environmental Engineering, there are faculty members with teaching and research interests in environmental problem solving in the Department of Chemical Engineering. The same is true in Departments of Biology, Chemistry, Earth and Environmental Sciences, and Mathematical Sciences, all of which fall within Rensselaer’s School of Science.

**Research and Innovation Initiatives**

**Earthquake Engineering (Civil)**

Rensselaer’s earthquake engineering research program is concerned with seismic analysis and design methodologies that mitigate the negative impact of earthquakes on buildings, bridges, and pipelines (water, sewer, gas, and oil). It also focuses on analytical relationships that support decision-making and advance the state of the art in design codes, a key to future sustainability and durability. In these areas, Rensselaer’s earthquake engineering research is among the best in the world. The Institute has a major geotechnical centrifuge facility and is in the process of building a medium-scale shaker table. The geotechnical centrifuge facility, fourth largest in the U.S. and among the twenty largest in the world, brings significant preeminence to the Institute. Rensselaer was recently selected as one of ten sites that will receive long-term NSF support as part of the Network for Earthquake Engineering Simulation initiative. Of major import in future research will be model-based simulation (using the centrifuge to extend existing simulation models and create new multiscale models), Web-based teleobservation and teleobservation (especially of a new robotic arm being built in collaboration with faculty from Mechanical, Aerospace, and Nuclear Engineering), and wireless sensors, using MEMs and other microelectronic devices (e.g., to unobtrusive-ly instrument experimental specimens).
Structural Engineering (Civil)
Design and analysis of bridges, buildings, and other large-scale facilities; material selection and specification; structural technology selection; dynamic and static structural modeling and analysis; environmental loads on structures.

Geotechnical Engineering (Civil)
Behavior of soils and foundations under cyclic and dynamic loads; design methods to accommodate natural and man-made vibrations; geostochastics; soil dynamics, stability of earth slopes, structures, and dams.

Transportation Engineering (Civil)
This area of research includes design, analysis, maintenance, and operation of transportation systems and facilities; intelligent transportation systems, especially highway networks, goods distribution systems, and transit systems; real-time, multiobjective network management and control, including route guidance and dynamic traffic assignment; signal control systems; network management strategies; multiobjective routing and scheduling; and logistics decision making under uncertainty.

Computational Mechanics (Civil)
Studies involve the development of automated finite element modeling techniques, adaptive analysis procedures, development of adaptive multiscale solution techniques, qualification and modeling of engineering idealizations for analysis and design, design systems using knowledge-base techniques, prototype systems for applications including discrete crack propagation, forging simulations, multiple-scale modeling of composite materials and electronic packages, and unsteady aerodynamics.

Infrastructure Engineering (Civil)
Under development are analytical methodologies and software tools for preservation, restoration, and renewal of large distributed systems such as roadways, bridges, pipelines, power distribution networks, and bridge and pavement management systems. Additional studies include remote sensing condition assessment, deterioration modeling and performance prediction, vulnerability assessment, risk analysis, reliability-centered maintenance, and capital investment planning.

Pollutant Fate and Transport (Environmental)
Research areas are conservative, semi-Lagrangian models of fate and transport in fluvial system, using scalable parallel algorithms for computation, probabilistic analysis of pollutant spills, influence of transient storage zones on fluvial fate and transport predictions, assessment of pathogen loading and transport in water supplies and treatment systems, fate of hydrophobic organics in sediment, environmental chemistry of PAHs.

Water Treatment (Environmental)
Researchers investigate the influence of natural organic matter properties and water chemistry on the formation of disinfection byproducts, understanding fouling mechanisms in the use of membrane processes in water treatment, membrane modifications for water treatment, adsorption processes and hybrid processes for removal of DBP precursors.

Waste Treatment (Environmental)
Studies focus on aerobic and anaerobic biological treatment reactors for municipal and industrial wastes; high strength anaerobic waste treatment in fluidized bed bioreactors with energy recovery, nutrient removal systems, hazardous waste treatment reactors, biofilters.
Site Remediation and Bioremediation (Environmental)
Research areas include combined advanced oxidation and biological treatment for sediment and soil slurry systems, in-situ degradation of chlorinated organics in groundwater, and solid phase treatment reactors for soils, slurries, and municipal solid wastes.

Environmental Systems (Environmental)
Under investigation are genetic algorithms for model calibration and optimization in environmental engineering, adaptive optimal control of treatment reactors, molecular modeling in environmental chemistry, and structure activity relationships.

Research Facilities
Rensselaer’s centrifuge was commissioned in 1989 and began conducting physical model simulations of soil and soil structure systems subjected to in-flight earthquake shaking in 1991. In over a decade of successful operation, the facility has published results of some 360 earthquake-related model simulations, served as the basis for 12 Ph.D. theses at Rensselaer (10 Ph.D. theses in the last five years), and contributed to Institute faculty and student research as well as that of dozens of visiting scholars and outside users from the U.S., Asia, Europe, and Latin America. It has also provided data and research results to many people and organizations around the world. This centrifuge earthquake research has been conducted with two existing one-dimensional in-flight shakers, which can accommodate 90 kg and 400 kg payloads respectively.

The next-generation earthquake engineering capability for the Rensselaer centrifuge includes 1) a 2-D in-flight earthquake shaker (two prototype horizontal components) and associated 2-D laminar box container to allow for more realistic 2-D modeling; 2) a four degrees of freedom (4-D) robot capable of performing in-flight operations such as construction and excavation, pile driving, ground remediation, cone penetration, and static and cyclic loading tests without stopping the centrifuge; 3) a networked data acquisition system with Internet teleobservation/teleoperation capability, to be linked to the high-speed Rensselaer gigabit Ethernet backbone; 4) two high-speed cameras and image processing software; 5) development of a new generation of advanced and improved sensors capable of providing a better resolution of the measured model response; and 6) other equipment aimed at increasing the capability of the centrifuge to test a greater number and wider variety of earthquake engineering models.

A major upgrade in lab equipment and space for environmental engineering research and teaching has occurred through the establishment of the Keck Water Quality Laboratory, the National Science Foundation Environmental Colloid and Particle Laboratory, and the refurbishment of the Environmental Engineering Teaching Laboratory suite. Analytical equipment in these labs provides the capability for analysis and investigation of a wide variety of industrial processes, treatment processes, and polluted environments. This equipment gives students experience and expertise in treatability and toxicity studies, design and operation of bench-scale treatment systems, and investigation of a wide range of environmental quality parameters. The fate of specific compounds in the environment and in treatment processes can be analyzed by UV-VIS spectrophotometry, high pressure liquid chromatography, gas-liquid and gas chromatography with a number of specific and sensitive detectors, including electron capture, flame ionization, thermal conductivity, and mass spectral. Metals analyses by atomic absorption spectrophotometry and elemental analyses are also available. A complete suite of water quality monitoring equipment, field sampling systems, and geographical information system tools are available. Computational capabilities are widely accessible not only throughout the campus, but also in research laboratories, as well.
Faculty*

Professors
Clesceri, N.L.—Ph.D. (University of Wisconsin); advanced waste treatment, environmentally sound manufacturing, sediment decontamination.

Dobry, R.—Sc.D. (Massachusetts Institute of Technology); geotechnical engineering, soil dynamics, earthquake engineering, seismic analysis.

Dvorak, G.J.—Ph.D. (Brown University); mechanics of solids, composite materials and structures, fracture and fatigue.

Feeser, L.J.—P.E., Ph.D. (Carnegie Mellon University); structures, computer applications and computer graphics, computer-aided design, structural optimization.

Fish, J.—Ph.D. (Northwestern University); computational mechanics, finite element methods, micro-mechanics, mathematical modeling.

Grivas, D.A.—Ph.D. (Purdue University); infrastructure engineering and management, nondestructive evaluation, mathematical morphology, image analysis, probabilistic modeling, risk analysis, reliability centered maintenance, mobility engineering.

List, G.F.—P.E., Ph.D. (University of Pennsylvania); intelligent transportation systems, sensors, instrumentation and control, multiobjective.

O’Rourke, M.J.—P.E., Ph.D. (Northwestern University); structures, lifeline earthquake engineering, snow loading on structures.

Shephard, M.S.—Ph.D. (Cornell University); computational mechanics, parallel processing, adaptive finite element techniques, automatic mesh generation.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute); decision support systems, the process of modeling, environmental management, disaster management.

Zimmie, T.F.—P.E., Ph.D. (University of Connecticut); geoenvironmental engineering, geotechnical engineering, groundwater hydrology, flow through porous media, landfills, centrifuge modeling, geosynthetics.

Associate Professors
Holguín-Veras, J.—P.E. Ph.D. (The University of Texas at Austin); intelligent transportation networks, intermodal transportation, transportation planning and modeling, transportation economics.

Kilduff, J.—Ph.D. (University of Michigan); physicochemical processes, separations and recovery processes in water and wastewater treatment, effects of adsorption and mass-transfer on pollutant fate and transport in natural systems, membrane processes for water quality control.

Symans, M.—Ph.D. (State University of New York at Buffalo); structural dynamics, earthquake engineering, seismic isolation and energy dissipation systems, structural vibration control.

Assistant Professors
Nyman, M.C.—Ph.D. (Purdue University); fate and transport of hydrophobic organic contaminants in natural systems, environmental chemistry.

Zeghal, M.—Ph.D. (Princeton University); soil dynamics and geotechnical earthquake engineering, computational geomechanics, geotechnical system identification and seismic response monitoring, damage diagnosis and nondestructive evaluation, and seismic risk analyses.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Research Assistant Professor
Abdoun, T.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering.

Clinical Associate Professor
Komisar, S.J.—Ph.D. (University of Washington); wastewater treatment, biological processes.

Adjunct Faculty (Civil Program)
Dall, J.—M.S. (Rensselaer Polytechnic Institute); structural engineering.
Dunn, R.H.P.—M.S. (Rensselaer Polytechnic Institute); geotechnical engineering.
Floess, C.—Ph.D. (Rensselaer Polytechnic Institute); geotechnical engineering.
Kenneally, D.—B.S. (Rensselaer Polytechnic Institute); highway engineering.
O’Malley, D.—M.S. (Central Missouri State University); traffic engineering.
Griggs, F.—D.E. (Rensselaer Polytechnic Institute); structural engineering.
Reilly, J.—Ph.D. (Rensselaer Polytechnic Institute); transportation systems.

Adjunct Faculty (Environmental Program)
Hetling, L.—P.E., Ph.D. (Rensselaer Polytechnic Institute) water resources.
Young, K.—J.D. (Harvard Law School) environmental law.

Undergraduate Programs
Civil Engineering Curriculum

Objectives of the Undergraduate Curriculum
While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, the Department of Civil and Environmental Engineering Department’s baccalaureate program in Civil Engineering will:

▪ Prepare students to be involved, global citizens with a broad appreciation of the key civil engineering issues and challenges of the 21st Century
▪ Provide students with the technical background needed for the practice of civil engineering and to ensure their competence and literacy in both problem identification and problem solving, including design.
▪ Prepare students for leadership in the profession, including civil engineering practice, societal activities, research, licensing, and ethics.
▪ Provide students with a broad educational base, including a foundation in math, science, and engineering and exposure to the humanities and social sciences that prepares them for life-long learning
▪ Prepare students to thrive in the modern workplace and the public forums of civil engineering practice through the development of leadership, teamwork, and communication skills

After completing the core engineering sequence, a student enters this curriculum and follows a baccalaureate program leading to the B.S. degree or a professional program leading to the M.Eng. degree as well as the B.S.

Undergraduate concentrations include construction, environmental, geotechnical, structural, and transportation engineering. Following the sample four-year schedule is the recommended collection of courses for each of these concentrations.
Subject to other requirements, students may use core engineering electives to accelerate their entrance into the program. Students also may take courses in related fields. Courses bearing the following codes are suggested for particular consideration in consultation with the student’s adviser: ARCH, ECSE, MANE, ENVE, MATH, CSCI, ERTH, and DSES.

The following represents a typical four-year civil engineering program. Students who are convinced that they want to become civil engineers are urged to follow this plan of study in lieu of the general core engineering program presented earlier. Required or strongly recommended core engineering electives are shown for optimum scheduling.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis ..........4</td>
<td>ENGR-1300</td>
<td>Engineering Processes 1 ..............1</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ........................................4</td>
<td>PHYS-1100</td>
<td>Physics I ........................................4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemical Principals for Engineers ..........4</td>
<td>MATH-1020</td>
<td>Calculus II ........................................4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
<td></td>
<td>Science Elective 2 .........................4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1300</td>
</tr>
<tr>
<td>PHYS-1100</td>
</tr>
<tr>
<td>MATH-1020</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design ..........4</td>
<td>ENGR-2090</td>
<td>Engineering Dynamics ........................................4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations ........4</td>
<td>ENGR-2530</td>
<td>Strength of Materials ........................................4</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II .........................4</td>
<td></td>
<td>Multidisciplinary Elective I 3 .............4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
<td></td>
<td>Beginning C Programming for Engineers 4 .........................1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2090</td>
</tr>
<tr>
<td>ENGR-2530</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL-2030</td>
<td>Intro. to Transportation Eng. ..........4</td>
<td>Multidisciplinary Elective II 4 .............4</td>
<td></td>
</tr>
<tr>
<td>CIVL-2630</td>
<td>Intro. to Geotechnical Eng. ..........4</td>
<td>CE Design Elective 5 .....................3</td>
<td></td>
</tr>
<tr>
<td>CIVL-2670</td>
<td>Intro. to Structural Eng. ..........4</td>
<td>Professional Development II 6 ...........2</td>
<td></td>
</tr>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty ..........3</td>
<td>Math and Science Elective ..........3-4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Free Elective ..........4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multidisciplinary Elective II 4 .............4</td>
</tr>
<tr>
<td>CE Design Elective 5 .....................3</td>
</tr>
<tr>
<td>Professional Development II 6 ...........2</td>
</tr>
<tr>
<td>Math and Science Elective ..........3-4</td>
</tr>
<tr>
<td>Free Elective ..........4</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL-4120</td>
<td>CE Instrumentation and Sensors ..........4</td>
<td>ENGR-4010</td>
<td>Professional Development III 7 ...........1</td>
</tr>
<tr>
<td></td>
<td>CE Design Elective 1 ..........3</td>
<td></td>
<td>CE Technical Elective 1 .....................3</td>
</tr>
<tr>
<td></td>
<td>Free Elective ..........4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Free Elective ..........4</td>
</tr>
</tbody>
</table>

1 For these two courses, order does not matter.

2 Choose either ENGR-1600 or CSCI-1100.

3 For Multidisciplinary Elective I, choose either ENGR-2250 or ENGR-4750. For Multidisciplinary Elective II, choose either ENGR-2350 or ENGR-4300.

4 Can be satisfied with Computer Science I.

5 Text below lists the allowable courses.

6 This course will be fulfilled from a list published at the start of each semester.

7 Can be taken either semester of the senior year.
A minimum of 128 credit hours is required for this curriculum. Nonengineering courses graded satisfactory/unsatisfactory are not included within this 128-credit-hour requirement. The Pass/No Credit option can be used only for free electives with something other than a CIVL or ENVE code and the humanities and social sciences electives. All other courses used to satisfy the degree requirements must be taken on a graded basis.

**Civil Engineering Design Electives and Concentrations**

Six credit hours of civil engineering design electives are required. These must be selected from the following list. Any pair of courses can be selected providing that prerequisites are met, but students most often select a combination focused on a specific area of concentration. The terms in which courses are offered are listed in parentheses.

**Construction Engineering**

- CIVL-4070 Steel Design (Fall)
- CIVL-4080 Concrete Design (Spring)
- CIVL-4010 Foundation Engineering (Fall)
- CIVL-4150 Experimental Soil Mechanics (Spring)
- CIVL-4200 Solid and Hazardous Waste Engineering
- CIVL-4350 Biological Processes in Environmental Engineering
- ENVE-4310 Applied Hydrology and Hydraulics
- ENVE-4340 Physicochemical Processes in Environmental Engineering

**Geotechnical Engineering**

- CIVL-4010 Foundation Engineering (Fall)
- CIVL-4140 Geoenvironmental Engineering (Fall)
- CIVL-4150 Experimental Soil Mechanics (Spring)

**Structural Engineering**

- CIVL-4070 Steel Design (Fall)
- CIVL-4080 Concrete Design (Spring)
- CIVL-4010 Foundation Engineering (Fall)
- CIVL-4150 Experimental Soil Mechanics (Spring)
- CIVL-4200 Solid and Hazardous Waste Engineering
- CIVL-4350 Biological Processes in Environmental Engineering
- ENVE-4310 Applied Hydrology and Hydraulics
- ENVE-4340 Physicochemical Processes in Environmental Engineering

**Environmental Engineering**

- CIVL-4620 Mass Transit Systems (Spring)
- CIVL-4640 Transportation Facility Design and Planning (Spring)
- CIVL-4660 Traffic Engineering (Fall)
- CIVL-4670 Highway Engineering (Spring)

**Civil Engineering Technical Elective**

Any of the design electives listed above can be taken as a CE technical elective, provided the necessary prerequisites are met. The following other civil engineering courses can also be selected:

- CIVL-2040 Professional Practice
- CIVL-2130 Surveying
- CIVL-4200 Solid and Hazardous Waste Engineering
- CIVL-4240 Intro. to Finite Elements
- CIVL-4270 Construction Management
- CIVL-4440 Structural Analysis
- CIVL-4580 Infrastructure Engineering

With adviser approval, courses from related disciplines can also be taken. These include architecture, environmental engineering, mechanical engineering, chemical engineering, industrial engineering, and operations research. Graduate level courses (6000-level) are allowable under certain circumstances. A representative list of such courses is as follows:

- ARCH-4510 Construction Industry Seminar
- ARCH-4530 Systems Building Seminar
- ARCH-4550 Building Economics
- ARCH-4750 Advanced Environmental Systems
- ENGR-4750 Engineering Economics and Project Management
- ENVE-4110 Aqueous Geochemistry
- ENVE-4200 Solid and Hazardous Waste Engineering
- ENVE-4310 Applied Hydrology and Hydraulics
- MATH-4800 Numerical Computing
- ERTH-2120 Structural Geology
- ERTH-2330 Earth Materials
- ERTH-4200 Surficial Geology
- ERTH-4710 Ground Water Hydrology

1 Special topics course.
Humanities or Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Environmental Engineering Curriculum

Objectives of the Undergraduate Curriculum
While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, the Civil and Environmental Engineering Department’s baccalaureate program in Environmental Engineering will:

■ Prepare students to be involved global citizens with a broad appreciation of the key environmental issues and challenges of the 21st Century
■ Provide students with a broad educational base, including a foundation in math, science, and engineering and exposure to the humanities and social sciences that will prepare them for life-long learning
■ Provide students with the technical background needed for the practice of environmental engineering and to insure their competence and literacy in both problem identification and solving, including design.
■ Prepare students for professional engineering practice, including professional licensing, with awareness of the importance of personal and professional ethics
■ Prepare students to thrive in the modern workplace and the public forums of environmental engineering practice through the development of leadership, teamwork, and communication skills

The Rensselaer bachelor’s program in environmental engineering builds upon a broad base of studies in chemistry, life sciences, and engineering sciences culminating in a uniquely structured course sequence. This sequence of courses, as shown below, is designed around the unit operations and transport processes concepts, together with integrated laboratory theory courses. It culminates in senior design courses. This structure presents a unified educational experience in environmental engineering. A minimum of 128 credit hours is required for this curriculum.

First Year

Fall
ENGR-1100 Intro. to Engineering Analysis ..........4
MATH-1010 Calculus I ..........................................4
CHEM-1300 Chemistry Principles for Engineers ....4
ENGR-1200 Engineering Graphics and CAD 1......1
Hum. or Soc. Sci. Elective .................................4

Spring
PHYS-1100 Physics I ...........................................4
MATH-1020 Calculus II .......................................4
ENGR-1600 Material Science for Engineers.........4
ENGR-1300 Engineering Processes or
Intro. to Eng. Electronics 1 ..............................1
Hum. or Soc. Sci. Elective .................................4

1 May be taken in any order in the first two semesters.
### Concentrations

In consultation with the program adviser, students may choose from four areas of concentration, emphasizing water quality control, air resources, environmental systems, and solid and hazardous wastes.

### Minor Programs

The department offers minors in both civil and environmental engineering.

### Civil Engineering

Students not majoring in civil engineering may receive a minor in this field by completing 15 credit hours selected from the following list (subject to consultation with a department program adviser):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIVL-2030</td>
<td>Intro. to Transportation Engineering</td>
<td>CIVL-4150</td>
</tr>
<tr>
<td>CIVL-2630</td>
<td>Intro. to Geotechnical Engineering</td>
<td>CIVL-4070</td>
</tr>
<tr>
<td>CIVL-2670</td>
<td>Intro. to Structural Engineering</td>
<td>CIVL-4080</td>
</tr>
<tr>
<td>ENVE-2110</td>
<td>Intro. to Environmental Engineering</td>
<td>CIVL-4660</td>
</tr>
<tr>
<td>CIVL-4010</td>
<td>Foundation Engineering</td>
<td>CIVL-4670</td>
</tr>
<tr>
<td>CIVL-2400</td>
<td>Intro. to Differential Equations</td>
<td>CIVL-4150</td>
</tr>
<tr>
<td>ENVE-2110</td>
<td>Intro. Environmental Eng</td>
<td>CIVL-4070</td>
</tr>
<tr>
<td>CHEM-2270</td>
<td>Intro. to Organic Chemistry</td>
<td>CIVL-4080</td>
</tr>
<tr>
<td>CIVL-4150</td>
<td>Experimental Soil Mechanics</td>
<td>CIVL-4660</td>
</tr>
<tr>
<td>CIVL-4070</td>
<td>Steel Design</td>
<td>CIVL-4670</td>
</tr>
<tr>
<td>CIVL-4080</td>
<td>Concrete Design</td>
<td>CIVL-4670</td>
</tr>
<tr>
<td>CIVL-4660</td>
<td>Traffic Engineering</td>
<td>CIVL-4670</td>
</tr>
</tbody>
</table>

1. May be taken in any order in the first two semesters.

2. Special section for environmental engineering students.

3. Elective must be an engineering course with design content (e.g., ENVE-4200, ENVE-4240, ENVE-4210, ENVE-4110). Courses are selected in consultation with the program adviser.

4. Multidisciplinary engineering elective: Must be an engineering course, (e.g., ENGR-4750, ENGR-4760, CIVL-2030, CIVL-2630, DSES-4260, ENGR-2530, ENGR-2830).

5. This course will be fulfilled from a published list at the start of each semester and can be taken either semester.
Students pursing this minor must satisfy the prerequisites and/or corequisites for these courses, which may involve other course work. Courses in mechanics and structures taught by the School of Architecture may be substituted for certain core engineering, mathematics, and mechanics/materials courses (with instructor approval).

**Environmental Engineering**

Students not majoring in environmental engineering may receive a minor in this discipline by completing 15–16 credit hours of study beyond the Introduction to Environmental Engineering course. Typically these courses are chosen in consultation with the environmental engineering program adviser but may include:

- ENVE-4260 Biological Processes in Environmental Engineering
- ENVE-4340 Physicochemical Process in Environmental Engineering
- ENVE-4310 Applied Hydrology and Hydraulics

And one or more of:

- ENVE-4200 Solid and Hazardous Waste
- ENVE-4330 Atmospheric Pollution
- ENVE-4320 Environmental Chemodynamics

**Professional Program**

This program is intended primarily as a preparation for professional practice. After core engineering study, qualified undergraduates may enter this program, which leads to the B.S. and the M.Eng. degrees. Students follow a coherent program integrating advanced undergraduate and graduate study. An additional 30 credit hours are required beyond the B.S. degree.

**Graduate Programs**

Graduate programs leading to the M.Eng., M.S., D.Eng., and Ph.D. are available in both curricula. The selection of a graduate program and degree is based on student interest, area of graduate concentration, and satisfaction of prerequisites as indicated below.

**Master’s Programs**

**Master of Science**

This research degree is open to students with undergraduate degrees in engineering or the physical or natural sciences. In addition to the satisfactory completion of an approved set of advanced courses, candidates for this degree must complete a six-credit thesis.

In the civil engineering discipline, this thesis must provide documentation of an independent research-related effort and be approved by the student’s faculty adviser. Listed below are recommended core courses in each of the five civil engineering areas of concentration. M.S. candidates typically take all the courses listed below in their chosen area of concentration.

**Computational Mechanics**

- CIVL-6170 Mechanics of Solids
- CIVL-6660 Fundamentals of Finite Elements
- CIVL-6670 Nonlinear Finite Element Methods
- CIVL-6680 Finite Element Programming

**Geotechnical/Earthquake Engineering**

- CIVL-6510 Advanced Soil Mechanics
- CIVL-6520 Advanced Foundations of Earth Structures
- CIVL-6550 Advanced Geoenvironmental Engineering
- CIVL-6450 Structural Dynamics

**Structural/Earthquake Engineering**

- CIVL-6540 Dynamics of Soil and Soil Foundations Systems

- CIVL-4240 Introduction to Finite Elements
- CIVL-6200 Plates and Shells
- CIVL-6210 Structural Stability
- CIVL-6310 Advanced Concrete Structures
- CIVL-6320 Advanced Steel Design
- CIVL-6450 Structural Dynamics
- CIVL-6540 Dynamics of Soil and Soil Foundation Systems
M.S. candidates in the environmental engineering discipline must also provide documentation of an independent research-related effort. In addition to approval of this written work, they are also required to give an oral presentation of the thesis work.

Master of Engineering
This is a 30-credit structured program of advanced professional study aimed at preparing students for professional practice. Except for computational mechanics, candidates for this degree in the civil engineering discipline must have an accredited bachelor’s degree in engineering. In environmental engineering, a B.S. in the physical or natural sciences is also acceptable. There is no project or thesis requirement, but students may elect to do one, at either the three- or six-credit level, in consultation with their advisers.

Doctoral Programs
Advanced study and research are conducted under the guidance of an adviser. Usually 45 to 60 course credits beyond the bachelor’s degree are required in addition to the residence and thesis requirements. Each doctoral candidate must have at least 90 credits (course work plus thesis/project) beyond the bachelor’s degree. Environmental candidates are required to submit a draft of a journal article prior to graduation.

Doctor of Philosophy
This is a research-oriented degree focused on the development of new knowledge in the student’s chosen area of study. It includes the preparation of a dissertation that carefully documents the original contribution of the student’s research. The dissertation can represent up to 30 credits of the student’s approved plan of study. In addition to the examination processes required of all Rensselaer doctoral students, civil engineering and environmental students working toward this degree must pass a preliminary examination during their first year of doctoral study.

Environmental engineering students must also take a candidacy examination within two semesters after passing the preliminary examination. This is an oral examination based on a thesis proposal submitted by the student at least two weeks prior to the examination. The student’s thesis committee will administer the candidacy examination.

Doctor of Engineering
This is a specialized program aimed at advanced engineering problem solving. The degree includes the preparation of a dissertation that poses a significant engineering problem and develops a solution. The dissertation for this degree can also represent up to 30 credits of the student’s approved plan of study. The examination requirements for both disciplines are the same as those noted under the Doctor of Philosophy.

Course Descriptions
Courses directly related to all Civil and Environmental Engineering curricula are described in the Course Description section of this catalog under the department codes CIVL and ENVE.
Decision Sciences and Engineering Systems

Chair: James M. Tien

Associate Chair and Director, Master's Programs: Charles J. Malmborg

Director, Doctoral Program: Sunderesh Heragu

Department Home Page: http://www.rpi.edu/dept/dses/www/

The formation of the Decision Sciences and Engineering Department in 1987 is a prime example of Rensselaer’s ability to anticipate the changing needs of the engineering profession. The department was created to (1) prepare engineers to design, develop, and implement complex systems and (2) to conduct research that leads to better understanding of how information technology and quantitative analysis and modeling can support individuals, groups, and systems in problem solving and decision making. DSES achieves these objectives by extending and integrating knowledge from the disciplines of industrial engineering, information systems, operations research, mathematical statistics, computational intelligence, bioinformatics, and systems engineering.

The Department of Decision Sciences and Engineering Systems offers programs in industrial and management engineering, manufacturing systems engineering, and operations research and statistics. Curricula in management engineering and/or industrial engineering have been offered since 1933. The interdisciplinary graduate program in operations research and statistics (OR&S) at Rensselaer was established in response to the rapid increase in the use of mathematical models for characterizing systems, understanding operations, and making decisions. Both a master’s and a doctoral program were initiated in 1967. However, in 1988, the department replaced the OR&S Ph.D. with a unique Ph.D. degree in Decision Sciences and Engineering Systems, reflecting the focus of the new department. The program in Manufacturing Systems Engineering was inaugurated in the fall of 1992. This program is designed to emphasize modeling, statistical, computer, and management skills as they relate to the process of manufacturing. A common theme throughout these programs is the use of mathematical, statistical, and computational/simulation models to better understand engineering, managerial, operational, and physical processes.

Research and Innovation Initiatives

Manufacturing Systems

Faculty have developed methodologies and procedures for infrastructure and operating systems (e.g., production planning and control, scheduling, and dispatching in flexible manufacturing systems), simulation of production facilities, manufacturing logistics, materials handling engineering, manufacturing facility design, information integration for design and manufacturing, control systems and agile manufacturing concepts for the electronics industry, and methodologies to integrate statistical quality control with computer graphics.

Service Systems

This area concentrates on the application of traditional and evolving industrial and systems engineering methodologies to the design and operation of service systems in both industry and the public sector. Areas of interest include simulation modeling and analysis, distribution and logistics, facilities design, work design, quality assurance, intelligent transportation systems, and engineering economic analysis. Also included is research in the deployment, allocation, and operation of urban service systems using computationally-intensive, real-time decision support approaches.
Information Systems
Information and decision support systems have been developed and extensively used for disaster preparedness and management of disasters (e.g., searches for ships lost at sea, earthquakes) and manufacturing enterprises (e.g., manufacturing-driven design and scalable adaptive integration of databases over wide area networks). New theory and methodologies for Internet-based information integration, e-commerce, data mining, and knowledge discovery are being developed. Decision support systems are being developed using a variety of knowledge engineering and computational intelligence tools. Also under development are methods, models, and technologies to aid in the planning and design of distributed information systems, information visualization, and user interfaces.

Mathematical Programming
Research topics include linear, nonlinear, integer, large-scale, multiple-objective, combinatorial, geometric, and stochastic programming. Of particular interest is research on the development and analysis of algorithms, computation, and the integration of uncertainty in optimization.

Statistics and Applied Probability
Research is conducted in the areas of real-time data fusion and analysis, data mining, knowledge discovery, and design of experiments—including optimality, efficiency, and robustness; nonlinear and robust estimation; statistical computing; probability; stochastic processes; queueing theory; reliability; quality control; and forecasting.

Facilitating these research programs are three research centers based directly within the Decision Sciences and Engineering Systems Department. Every department faculty member is involved in one or more of these research centers. In addition, several other faculty in the School of the Engineering, as well as in the other four schools, are also participating in activities conducted in the centers described below:

Electronics Agile Manufacturing Research Institute (EAMRI)
The EAMRI grew out of a federally funded, five-year project focused on agile manufacturing information technologies as a strategy to help the electronics manufacturing industry achieve its goals. Agile manufacturing concepts employ network-based information for supply chain-oriented technologies and organizations, as well as improved communications to help solve design and manufacturing problems. The EAMRI provides a national focus for developing and sharing methods to enable the U.S. electronics industry to adopt agile manufacturing. Experts in electronics design and manufacturing, the EAMRI faculty possess engineering, computer science, and management backgrounds. The EAMRI’s initial information technology, known as the Virtual Design Environment, has recently received a patent from the U.S. Patent Office.

Center for Services Research and Education (CSRE)
The goal of the CSRE is to enhance our understanding of the service sector and its function, and to educate students and managers seeking careers in the services industry, which accounts for more than three-quarters of the U.S. gross national product. CSRE faculty were one of the first groups to highlight the duality between services and manufacturing; many manufacturing methods are applicable to service systems and can be employed to enhance productivity and competitiveness. The CSRE takes a holistic approach to the multifaceted service sector and brings together experts from engineering, marketing, psychology, economics, and management policy and organization, among others. Experts examine the common elements that characterize all aspects of the service sector and develop generic principles that apply across the wide spectrum of services, including the advancement of a focus in service systems engineering.
Rensselaer Statistical Consulting Center (RSCC)
The RSCC provides statistical planning and analysis services to Rensselaer researchers who require them. It also consults with companies and government agencies that require advice on state-of-the-art statistical and probabilistic methods and their applications. In addition, it allows graduate students to apply, in a supervised manner, established and new statistical and probabilistic approaches to real-world problems, and offers general and organization-specific short-term training programs and state-of-the-art courses in statistical methodologies and practices. The Center’s faculty represent a range of statistical expertise, and they have extensive research and consulting experience. These faculty members, together with talented graduate students, provide advice and guidance on the appropriate use of statistical and probabilistic methods, on a consulting or short course basis.

Faculty*

Professors

Berg, D.—NAE, Ph.D. (Yale University) Institute Professor of Science and Technology (joint in Lally School of Management and Information Technology); management of technological organizations, innovation, policy, robotics, policy issues of research and development in the service sector.

Ecker, J.G.—(Mathematical Sciences) Ph.D. (University of Michigan); mathematical programming, multiobjective programming, geometric programming, mathematical programming applications, ellipsoid algorithms.

Grabowski, M.—Ph.D. (Rensselaer Polytechnic Institute); management information systems, knowledge-based systems, human and organizational error in large-scale systems, impact of information technology on systems and organizations; Research Professor.

Graves, R.J.—Ph.D. (State University of New York at Buffalo); manufacturing systems modeling and analysis, facilities planning and material handling system design, scheduling systems, concurrent engineering and design for manufacture, continuous flow manufacturing systems design, distributed manufacturing concepts, information infrastructure.

Hsu, C.—Ph.D. (Ohio State University); electronic commerce, metadatabase and information systems, enterprise integration and modeling, internet enterprises planning, computerized manufacturing, information visualization, economic evaluation of cyberspace-augmented enterprises.

Hughes, G.—(Economics) Ph.D. (Princeton University); global economics, economics of information technology; Clinical Professor.

List, G.F.—(Civil Engineering) P.E., Ph.D. (University of Pennsylvania); real-time control of transportation network operations; multiobjective routing, scheduling, and fleet sizing; operations planning; hazardous materials logistics.

Malmborg, C.J.—Ph.D. (Georgia Institute of Technology); modeling and analysis of problems in facility design, materials handling, material flow, storage systems, simulation-based optimization methods, manufacturing systems, decision analysis.

Raghavachari, M.—Ph.D. (University of California at Berkeley); statistical inference, quality control, multivariate methods, scheduling problems.

Tien, J.M.—NAE, Ph.D. (Massachusetts Institute of Technology) Yamada Corporation Professor (joint in Electrical, Computer, and Systems Engineering; IT); systems modeling, queueing theory, public policy and decision analysis, computer performance evaluation, and information and decision support systems, expert systems, computational cybernetics.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute) (joint in Civil Engineering; Cognitive

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Sciences; IT); decision support systems, environmental management modeling process, disaster management.

**Willemain, T.R.**—Ph.D. (Massachusetts Institute of Technology); probabilistic modeling, data analysis, forecasting.

**Associate Professors**

**Embrechts, M.J.**—Ph.D. (Virginia Polytechnic Institute); application of neural networks and fuzzy logic for manufacturing and process control; image recognition and classification with the aid of neural networks; smart experiments; neural networks for trading and finance; neural networks, fractals, chaos, and wavelets for time-series analysis; data mining and computational intelligence.

**Foley, W.J.**—PE., Ph.D. (Rensselaer Polytechnic Institute); engineering design, computer simulation modeling, health applications of operations research, health care policy analysis; Clinical Associate Professor.

**Heragu, S.S.**—Ph.D. (University of Manitoba); artificial intelligence, cellular manufacturing, facilities design, intelligent manufacturing systems, materials handling, next-generation factory layout design, production and operations management, operations research, scheduling, storage and warehousing.

**Holguin-Veras, J.**—(Civil and Environmental); Ph.D. (University of Texas/Austin); transportation modeling and transportation economics, information technology, information systems, optimization techniques.

**Mitchell, J.E.**—(Mathematical Sciences) Ph.D. (Cornell University); mathematical programming, integer programming, interior point methods, column generation methods, financial optimization, stochastic programming.

**Sullo, P.**—Ph.D. (Florida State university); reliability, life testing, statistical quality control, quality management, biostatistics, industrial statistics.

**Assistant Professors**

**Aboul-Seoud, M.**—Ph.D. (University of Louisville); reliability engineering, quality control, operations research; Clinical Assistant Professor.

**Chang, W.**—Ph.D. (Georgia Institute of Technology); computational statistics using multiscale methods, signal/image processing in biomedical engineering, pattern recognition, and stochastic system modeling.

**Gupta, A.**—Ph.D. (Stanford University); behavioral aspects of optimization and application problems in finance, large-scale problems in decision making, simulation methods and tools for solving large-scale problems, simulation-based optimization.

**Krishnamurthy, A.**—Ph.D. (University of Wisconsin-Madison); queuing models and simulation based approaches for design and analysis of manufacturing systems, quick response manufacturing, queuing networks, analytical models in fabrication/assembly systems.

**Taner, M.**—Ph.D (North Carolina State University); e-commerce, production scheduling, distributed manufacturing systems; Clinical Assistant Professor.

**Yang, Y.**—(Cognitive Science) Ph.D. (New York University); cognitive psychology, thinking, reasoning, decision-making, cognitive science.

**Adjunct Faculty**

**Hahn, G.**—Ph.D. (Rensselaer Polytechnic Institute); applied statistics, operations research.

**Kupferschmid, M.**—PE., Ph.D. (Rensselaer Polytechnic Institute); mathematical programming, algorithm performance evaluation, engineering applications.

**Lawrence, C.**—Ph.D. (Cornell University); statistical methods for bioinformatics, biometrics, Bayesian statistics, sequential analysis, statistical computing.

**Mars, C.M.**—B.S. (Rensselaer Polytechnic Institute); industrial safety and hygiene.
Sandhu, D.—Ph.D. (University of Toronto); stochastic models in operations research, complex queuing networks, applications to communication and manufacturing systems.

Tucker, W.—Ph.D. (Oklahoma State); applied statistics, operations research, quality control.

**Affiliated Professors**

Desrochers, A.—(Electrical, Computer, and Systems Engineering) Ph.D. (Purdue University); performance modeling of automated manufacturing systems application to Petri nets, transfer lines, manufacturing architectures, database and network transactions, distributed systems.

Grivas, D.—(Civil Engineering) Ph.D. (Purdue University); engineering infrastructure asset management systems, infrastructure databases, applications of fuzzy sets and expert systems, probabilistic modeling, risk analysis, assessment, management.

Haddock, J.—(Lally School of Management); Ph.D. (Purdue University); mathematical and simulation modeling, just-in-time manufacturing, lean management techniques, corporate paradigms.

Kelly, L.J.—(Rensselaer at Hartford) Ph.D. (University of Connecticut); statistics, operations management; Clinical Associate Professor.

Norsworthy, J.R.—(Lally School of Management and Technology) Ph.D. (University of Virginia); economics of productivity, productivity measurements, industrial economics.

Paulson, A.S.—(Lally School of Management and Technology) Ph.D. (Virginia Polytechnic Institute); risk management, financial models, multivariate statistics, time series and forecasting, survival data analysis.

Simons, G.—(Lally School of Management); Ph.D. (Rensselaer Polytechnic Institute); manufacturing strategy and policy, technology strategies, infrastructure, application of network models.

**Affiliated Associate Professors**

Bennett, K.—(Mathematical Sciences) Ph.D. (University of Wisconsin); mathematical programming, operations research, artificial intelligence.

Franklin, W.R.—(Electrical, Computer, and Systems Engineering) Ph.D. (Harvard University); computational geometry, graphics, CAD, cartography, parallel algorithms, large databases, expert system verification.

Goldenberg, D.H.—(Lally School of Management and Technology) Ph.D. (University of Florida); derivatives markets, stochastic modeling of prices, options in corporate finance.

Gutierrez-Miravete, E.—(Rensselaer at Hartford) Ph.D. (Massachusetts Institute of Technology); materials processing, transport phenomena, clean technologies, advanced mathematics for applications, numerical computing, mathematical modeling, computer simulation.

Maleyeff, J.—(Rensselaer at Hartford) Ph.D. (University of Massachusetts); statistical quality assurance in manufacturing, administration and health care; computer simulation of operating systems; development of effective teaching methodologies.

Messac, A.—(Mechanical, Aerospace and Nuclear Engineering); Ph.D. (Massachusetts Institute of Technology); multiattribute design optimization, design and manufacturing, concurrent engineering.

**Affiliated Assistant Professor**

Arnheiter, E.D.—(Rensselaer at Hartford) Ph.D. (University of Massachusetts); Monte Carlo simulation and probabilistic models in quality, modular consortiums, and automotive production models.

Ravichandran, T.—(Lally School of Management and Technology) Ph.D. (Southern Illinois University, Carbondale); management information systems.

Zaki, M.J.—(Computer Sciences) Ph.D. (University of Rochester); design of efficient, scalable, and parallel algorithms for various data mining techniques.

**Emeritus Faculty**

Wilkinson, J.—Ph.D. (University of North Carolina); regression modeling, statistical analysis
Undergraduate Programs

Objectives of the Undergraduate Curriculum

While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences for some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, the Department of Decision Sciences and Engineering Systems baccalaureate program educates students in the fundamental theories, principles, methodologies and practices of Industrial and Management Engineering while seeking to develop in its graduates:

- The ability to apply a total integrated systems perspective to the practice of industrial and management engineering.
- The ability to apply knowledge of manufacturing and service systems to the practice of industrial and management engineering.
- The ability to apply in-depth knowledge of computing to the practice of industrial and management engineering.
- The ability to manage people and systems.
- The ability to design innovative products, services, facilities, equipment, processes and systems.
- The ability to identify, model, analyze, and solve challenging real-life problems.
- A solid foundation in math and science.
- Strong communication skills with emphasis on technical writing and interpersonal communication.
- The ability to perform effectively on diverse teams, both as leader and contributor.
- Informed citizens broadly educated in the humanities and social sciences.
- Preparation to practice engineering in a socially responsible and ethical manner.
- Motivation and preparation for continued growth and learning.

Baccalaureate Programs

The Department of Decision Sciences and Engineering offers a curriculum in Industrial and Management Engineering (IME). The first two years of this curriculum provide a strong foundation in basic science, engineering science, mathematics, and the humanities and social sciences. These two years are oriented toward the quantitative (mathematical) approach. Computer-based technology, including simulation, modeling, and systems design, is emphasized. In the last two years of the program, students concentrate on building expertise in statistics, operations research, manufacturing, systems engineering, and industrial engineering methods and models. Through the appropriate choice of electives, students can focus on their selected areas of interest. Design projects include problems in both manufacturing and service systems, including information and public systems. It is advisable to develop a plan of study leading to the desired degree and concentration by the beginning of the third year.

DSES recommends that students declare their intent to major in industrial and management engineering as early as possible in their academic career. Students are also urged to work closely with their assigned faculty advisers to ensure that all degree requirements are satisfied. This curriculum requires a minimum of 128 credit hours and completion of the course requirements shown in the typical four-year program presented below.
**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Introduction to Engineering Analysis</td>
<td>ENGR-1200</td>
<td>Engineering Graphics and CAD</td>
</tr>
<tr>
<td>ENGR-1300</td>
<td>Engineering Processes</td>
<td>MATH-1020</td>
<td>Calculus II</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>PHYS-1100</td>
<td>Physics I</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
<td></td>
<td>Science Elective</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design</td>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>DSES-2210</td>
<td>Production and Operations Mgmt. and Cost Accounting</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>Multidisciplinary Engineering Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control</td>
<td>DSES-4230</td>
<td>Quality Control</td>
</tr>
<tr>
<td>DSES-4140</td>
<td>Statistical Analysis</td>
<td>DSES-4650</td>
<td>Operations Research II</td>
</tr>
<tr>
<td>DSES-4640</td>
<td>Operations Research I</td>
<td></td>
<td>Multidisciplinary Engineering Elective</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
<tr>
<td></td>
<td>Professional Development II</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4100</td>
<td>Professional Development III</td>
<td></td>
<td>Technical Elective</td>
</tr>
<tr>
<td>DSES-4530</td>
<td>Information Systems</td>
<td></td>
<td>Technical Elective</td>
</tr>
<tr>
<td></td>
<td>Technical Elective</td>
<td></td>
<td>Free Elective</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td></td>
<td>Free Elective</td>
</tr>
</tbody>
</table>

1. Adviser approved course in science, computer science, or mathematics.
2. Students must select any two of the following approved multidisciplinary electives:
   - ENGR-1600
   - ENGR-2090
   - ENGR-2250
   - ENGR-2530
   - ENGR-2710
   - ENGR-4050
   - ENGR-4300

3. This course can be fulfilled by taking a two-credit course from a list of courses published at the start of each semester.
4. Students may select any three of the following courses to satisfy technical elective requirements (Note that certain graduate level DSES courses can also serve as technical electives for eligible undergraduates with permission of the instructor and the adviser):
   - DSES-4200
   - DSES-4250
   - DSES-4260
   - DSES-4810
   - DSES-4280

5. May be taken in either fall or spring semester.
Electives
The free electives indicated above may be chosen from any academic discipline to broaden the student’s educational background and/or develop greater depth in a selected discipline.

Humanities and Social Sciences Electives
The electives in this area are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Special Undergraduate Opportunities

Cooperative Education Program
DSES encourages this option, which allows students to gain professional experience as part of the educational program. Additional information on co-op opportunities is included in the Educational Programs and Resources section of this catalog, as well as through the faculty adviser or the Career Development Center.

Graduate Programs

Master’s Programs
The Department of Decision Sciences and Engineering Systems offers two master’s level degrees, both of which can be earned within each of three curricula. These curricula and their individual requirements are described below.

Industrial and Management Engineering (IME) Curricula
Students can work toward either the M.S. degree, which requires a project or thesis, or the nonthesis M.Eng. degree. These IME degrees are also available through distance learning. Contact the Office of Professional and Distance Education for course scheduling information.

In general, all applicants to the IME master’s programs must take the Graduate Record Exam (GRE). This requirement is especially important for those requesting financial aid, due to the large number of aid requests. However, for students applying to the M.Eng. program, the GRE may sometimes be waived. In special situations, and with departmental approval, the GMAT may be substituted for the GRE.

All students seeking either of the IME master’s degrees must have completed the following two courses in their undergraduate program at Rensselaer or have had the equivalent courses elsewhere:
- Applied Operations Research (equivalent to DSES-6960 Systems Modeling and Decision Sciences)
- Introduction to Applied Statistics (equivalent to DSES-6110)

Both IME master’s degrees require a minimum of 30 credit hours.

In addition to the above prerequisite courses, a student’s core course work must include:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6470</td>
<td>Global Strategic Management of Technological Innovation</td>
<td>DSES-6620</td>
<td>Service Logistics</td>
</tr>
<tr>
<td>DSES-6500</td>
<td>Information and Decision Technologies for Industrial and Service Systems</td>
<td>DSES-6xxx</td>
<td>Simulation Modeling and Analysis</td>
</tr>
<tr>
<td>DSES-6600</td>
<td>Models for Production Control and</td>
<td></td>
<td>Applied Statistics Elective (One graduate course from those listed under the Applied Probability and Statistics and Quality Control concentration.)</td>
</tr>
</tbody>
</table>
For students seeking the M.S. degree, three to nine of the 30 credit hours must be in DSES-6990 (Master’s Thesis) or DSES-6980 (Master’s Project). The thesis or project credits can also count toward the nine-credit-hour (three-course) concentration that the program requires.

While the remainder of the program may be tailored to the student's interest, the plan of study must include a concentration area. The concentration is a set of three or more courses (or nine credit hours) that reflects a logical progression for developing a base of expertise in an area of study. Concentrations will usually, but not always, include at least one of the core courses listed above. Listed below are several concentration areas and the courses that are within each area.

**Applied Operations Research Concentration**

- DSES-4770 Mathematical Models of Operations Research
- DSES-4780 Computational Optimization
- DSES-6050 Stochastic Processes
- DSES-6200 Models in Facilities Planning and Materials Handling
- DSES-6210 Theory of Production Scheduling
- DSES-6300 Simulation of Large-Scale Systems
- DSES-6630 Combinatorial Optimization and Integer Programming
- DSES-6770 Linear Programming
- DSES-6780 Nonlinear Programming
- DSES-6820 Queuing Systems and Applications
- DSES-6830 Large-Scale Systems: Case Studies and Analyses
- DSES-6840 Modeling Large-Scale Systems
- DSES-6850 Evaluation Methods for Decision Making
- DSES-6890 Multiple Criteria Decision Making

**Applied Probability and Statistics and Quality Control Concentration**

- DSES-4750 Probability Theory and Applications
- DSES-4760 Mathematical Statistics
- DSES-6010 Applied Regression Analysis
- DSES-6020 Design of Experiments
- DSES-6030 Sampling Methods
- DSES-6040 Nonparametric Methods
- DSES-6050 Stochastic Processes
- DSES-6060 Applied Multivariate Analysis
- DSES-6070 Statistical Methods for Reliability Engineering
- DSES-6090 Decision Analysis
- DSES-6100 Time Series Analysis
- DSES-6140 Exploratory Data Analysis
- DSES-6150 Advanced Probability for Statistical Inference

**Information Systems Concentration**

- DSES-4810 Computational Intelligence
- DSES-6220 Concurrent Engineering
- DSES-6500 Information and Decision Technologies for Industrial and Service Systems
- DSES-6520 Enterprise Database Systems
- DSES-6530 Decision Support and Expert Systems
- DSES-6550 Information Systems Analysis and Design
- DSES-6560 Information Technology and Systems for Enterprise Engineering
- DSES-6570 Information Technology and Systems for E-Business
- DSES-6870 Introduction to Neural Networks

**Management of Technology Concentration**

- MGMT-6160 New Ventures
- MGMT-6190 Financial and Managerial Accounting
- MGMT-6300 Business Economics
- MGMT-6310 Financial Management and Valuation of Firms
- MGMT-6600 Research and Development Management
- DSES-6470 Global Strategic Management of Technological Innovation
- DSES-6480 Service Operations Management
- DSES-6830 Large-Scale Systems: Case Studies and Analyses
- DSES-6860 Evaluation Methods for Decision Making
**Manufacturing Systems Concentration**

- DSES-4200 Design and Analysis of Work Systems
- DSES-4250 Facilities Design and Industrial Logistics
- DSES-6200 Models in Facilities Planning and Materials Handling
- DSES-6210 Theory of Production Scheduling
- DSES-6220 Concurrent Engineering
- DSES-6230 Quality Control and Reliability
- DSES-6560 Information Technology and Systems for Enterprise Engineering
- DSES-6600 Models for Production Control and Service Logistics

**Service Systems Concentration**

- DSES-6480 Service Operations Management and at least two courses from the list below:
  - DSES-6170 Management of Quality Processes and Reliability
  - DSES-6860 Evaluation Methods for Decision Making
  - DSES-6980 Master’s Project in Service Systems

**Manufacturing Systems Engineering (MSE) Curricula**

In this curriculum, DSES offers multidisciplinary M.S. and M.Eng. degrees in programs that combine modeling, statistical, computer, design, and management skills focused on the process of manufacturing. The programs provide students with an option to combine courses in DSES with concentration courses in electrical engineering, mechanical engineering, computer science, or management. Alternatively, students can elect to focus the entire plan of study in DSES. Course work concentrations are available in manufacturing systems modeling, manufacturing information systems, manufacturing systems quality, manufacturing processes and technology, and manufacturing systems management.

All applicants to this program are encouraged to take the Graduate Record Exam (GRE). This requirement is especially important for those requesting financial aid, due to the large number of aid requests. The GRE may be waived or the GMAT may be substituted for the GRE for students applying to the M.Eng. program.

All students seeking either of the MSE master’s degrees must have completed the following two courses in their undergraduate program at Rensselaer or have had the equivalent course elsewhere:
- Applied Operations Research (equivalent to DSES-6960)
- Introduction to Applied Statistics (equivalent to DSES-6110)

Both MSE master’s degrees require a minimum of 30 credit hours.

In addition to the above prerequisite courses, a student’s core course work must include:

- DSES-6220 Concurrent Engineering
- DSES-6230 Quality Control and Reliability
- DSES-6470 Global Strategic Management of Technological Innovation
- DSES-6560 Information Technology and Systems for Enterprise Engineering
- DSES-6620 Discrete-Event Simulation

For students seeking the M.S. degree, three to nine of the 30 credit hours must be in DSES-6990 (Master’s Thesis) or DSES-6980 (Master’s Project). The thesis or project credits can also count toward the nine-credit-hour (three-course) concentration that the program requires.

While the remainder of the program may be tailored to the student's interest, the plan of study must include a concentration area. The concentration is a set of three or more courses (or nine credit hours)

---

*Students can also satisfy this part of the requirement for the service systems concentration through two application-focused courses approved by the academic adviser. Examples of applications foci include financial services, health systems, transportation, retailing, public systems, quality systems, and marketing.*
that reflects a logical progression for developing a base of expertise in an area of study. Concentrations will usually, but not always, include at least one of the core courses listed above. Listed below are several concentration areas and the courses that are within each area.

<table>
<thead>
<tr>
<th>Manufacturing Systems Modeling Concentration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-6450 Modeling and Control of Automated Manufacturing Systems</td>
<td>CSCI-6470 Database Systems for Engineering Applications</td>
</tr>
<tr>
<td>DSES-4250 Facilities Design and Industrial Logistics</td>
<td>CSCI-6960 Network Programming</td>
</tr>
<tr>
<td>DSES-6200 Models in Facilities Planning and Materials Handling</td>
<td>DSES-4810 Computational Intelligence</td>
</tr>
<tr>
<td>DSES-6620 Continuous and Stochastic System Simulation</td>
<td>DSES-6500 Information and Decision Technologies for Industrial and Service Systems</td>
</tr>
<tr>
<td>DSES-6820 Queueing Systems and Applications</td>
<td>DSES-6520 Enterprise Database Systems</td>
</tr>
<tr>
<td>DSES-6830 Large-Scale Systems: Case Studies and Analyses</td>
<td>DSES-6530 Decision Support and Expert Systems</td>
</tr>
<tr>
<td>DSES-6840 Modeling Large-Scale Systems</td>
<td>DSES-6560 Information Technology and Systems for Enterprise Engineering</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manufacturing Processes and Technology Concentration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6010 Applied Regression Analysis</td>
<td>ECSE-4490 Fundamentals of Robotics</td>
</tr>
<tr>
<td>DSES-6020 Design of Experiments</td>
<td>ECSE-6410 Robotics and Automation Systems</td>
</tr>
<tr>
<td>DSES-6030 Sampling Methods</td>
<td>MTLE-4160 Semiconducting Materials</td>
</tr>
<tr>
<td>DSES-6040 Nonparametric Methods</td>
<td>MTLE-4420 Joining of Advanced Materials</td>
</tr>
<tr>
<td>DSES-6060 Applied Multivariate Analysis</td>
<td>MANE-4510 Metal Cutting</td>
</tr>
<tr>
<td>DSES-6070 Statistical Methods for Reliability Engineering</td>
<td>MANE-4550 Analysis of Manufacturing Processes</td>
</tr>
<tr>
<td>DSES-6100 Time Series Analysis</td>
<td>MANE-6120 Robotics</td>
</tr>
<tr>
<td>DSES-6140 Exploratory Data Analysis</td>
<td>MANE-6450 Mechanics of Materials Processing</td>
</tr>
<tr>
<td>DSES-6170 Management of Quality Processes and Reliability</td>
<td>MANE-6800 Manufacturing Systems Integration</td>
</tr>
<tr>
<td>DSES-6180 Introduction to Knowledge Discovery with Data Mining</td>
<td>DSES-4200 Design and Analysis of Work Systems</td>
</tr>
<tr>
<td>DSES-6230 Quality Control and Reliability</td>
<td>DSES-4260 Industrial Safety and Hygiene</td>
</tr>
<tr>
<td>DSES-6220 Concurrent Engineering</td>
<td>DSES-6220 Concurrent Engineering</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manufacturing Information Systems Concentration</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4670 Computer Communications Networks</td>
<td>MGMT-6490 Competitive Advantage and Operations Strategy</td>
</tr>
<tr>
<td>ECSE-4710 Interactive Computer-Aided Design</td>
<td>DSES-4240 Engineering Project Management</td>
</tr>
<tr>
<td>ECSE-4750 Computer Graphics</td>
<td>DSES-6470 Global Strategic Management of Technological Innovation</td>
</tr>
<tr>
<td>ECSE-6400 Systems Analysis Techniques</td>
<td>DSES-6480 Service Operations Management</td>
</tr>
<tr>
<td>ECSE-6610 Pattern Recognition</td>
<td></td>
</tr>
<tr>
<td>ECSE-6640 Digital Picture Processing</td>
<td></td>
</tr>
<tr>
<td>ECSE-6650 Computer Vision</td>
<td></td>
</tr>
<tr>
<td>ECSE-6770 Software Engineering I</td>
<td></td>
</tr>
<tr>
<td>ECSE-6780 Software Engineering II</td>
<td></td>
</tr>
</tbody>
</table>
For most students, the M.Eng. program of study will also allow for six credits of elective courses.

**Operations Research and Statistics Curricula**

In this curriculum, DSES offers M.S. and M.Eng. degree programs that combine course work in applied probability and statistics, optimization, modeling, and decision sciences in the scientific application of quantitative tools to support decision making. The scope of the programs includes the formulation, solution, and implementation of mathematical models of decision problems to measure, evaluate, and optimize system performance. Most students can complete either program in 30 credit hours. Any student planning to enroll in the DSES doctoral program should consult with the faculty adviser prior to making course selections.

The diversity of this curriculum’s faculty enables these programs to encompass varied research topics. A student may work simultaneously on a master’s degree in this program and on a degree in computer science, business administration, mathematics, computer and systems engineering, or another related area.

Most students participating in this curriculum hold a bachelor’s or master’s degree in engineering, mathematics, the physical sciences, business administration, or management. Students with training in other disciplines such as economics and the social sciences are also encouraged to apply if their quantitative backgrounds include the equivalent of at least three semesters of calculus and linear algebra.

All applicants are required to take the Graduate Record Examination (GRE) except under extenuating circumstances.

For the master’s programs in operations research and statistics, no prerequisites are required. However, the following courses or their equivalents are required.

### Credit hours

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4640</td>
<td>Operations Research I</td>
<td>4</td>
</tr>
<tr>
<td>DSES-4750</td>
<td>Probability Theory &amp; Applications</td>
<td>4</td>
</tr>
<tr>
<td>DSES-4760</td>
<td>Mathematical Statistics</td>
<td>4</td>
</tr>
<tr>
<td>DSES-6050</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6150</td>
<td>Advanced Probability for Statistical Inference</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6620</td>
<td>Discrete-Event Simulation</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6060</td>
<td>Applied Multivariate Analysis</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6140</td>
<td>Exploratory Data Analyses</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6820</td>
<td>Queuing Systems &amp; Applications</td>
<td>3</td>
</tr>
<tr>
<td>DSES-6920</td>
<td>Advanced Probability for Statistical Inference</td>
<td>3</td>
</tr>
</tbody>
</table>

While the remainder of the program may be tailored to the student’s interest, the plan of study must include a concentration area. The concentration is a set of three or more courses (or nine credit hours) that reflects a logical progression for developing a base of expertise in an area of study. Concentrations will usually, but not always, include at least one of the core courses listed above. Listed below are several concentration areas and the courses that are within each area.

* Any course listed under the Modeling/Optimization Concentration except DSES-4770.
<table>
<thead>
<tr>
<th>Quality and Reliability Concentration</th>
<th>Simulation Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-6020 Design of Experiments</td>
<td>DSES-6630 Continuous Stochastic System</td>
</tr>
<tr>
<td>DSES-6050 Stochastic Processes</td>
<td>DSES-6020 Design of Experiments</td>
</tr>
<tr>
<td>DSES-6070 Statistical Methods for Reliability Engineering</td>
<td>DSES-6050 Stochastic Processes</td>
</tr>
<tr>
<td>DSES-6150 Advanced Probability for Statistical Inference</td>
<td>DSES-6100 Time Series Analysis</td>
</tr>
<tr>
<td>DSES-6170 Management of Quality Processes and Reliability</td>
<td>DSES-6150 Advanced Probability for Statistical Inference</td>
</tr>
<tr>
<td>DSES-6230 Quality Control and Reliability</td>
<td>DSES-6820 Queuing Systems and Applications</td>
</tr>
<tr>
<td></td>
<td>DSES-6870 Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Forecasting Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON-6570 Econometrics</td>
</tr>
<tr>
<td>DSES-6010 Applied Regression Analysis</td>
</tr>
<tr>
<td>DSES-6060 Applied Multivariate Analysis</td>
</tr>
<tr>
<td>DSES-6100 Time Series Analysis</td>
</tr>
<tr>
<td>DSES-6130 Statistical Computing</td>
</tr>
<tr>
<td>DSES-6140 Exploratory Data Analysis</td>
</tr>
<tr>
<td>DSES-6150 Advanced Probability for Statistical Inference</td>
</tr>
<tr>
<td>DSES-6870 Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision Analysis Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4750 Probability Theory and Applications</td>
</tr>
<tr>
<td>DSES-6090 Decision Analysis</td>
</tr>
<tr>
<td>DSES-6500 Information and Decision Technologies for Industrial and Service Systems</td>
</tr>
<tr>
<td>DSES-6530 Decision Support and Expert Systems</td>
</tr>
<tr>
<td>DSES-6830 Large-Scale Systems: Case Studies and Analyses</td>
</tr>
<tr>
<td>DSES-6860 Evaluation Methods for Decision Making</td>
</tr>
<tr>
<td>DSES-6890 Multiple Criteria Decision Making</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modeling/Optimization Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4770 Mathematical Models of Operations Research</td>
</tr>
<tr>
<td>DSES-4780 Computational Optimization</td>
</tr>
<tr>
<td>DSES-6200 Models in Facilities Planning and Materials Handling</td>
</tr>
<tr>
<td>DSES-6210 Theory of Production Scheduling</td>
</tr>
<tr>
<td>DSES-6760 Combinatorial Optimization and Integer Programming</td>
</tr>
<tr>
<td>DSES-6770 Linear Programming</td>
</tr>
<tr>
<td>DSES-6780 Nonlinear Programming</td>
</tr>
<tr>
<td>DSES-6840 Modeling Large-Scale Systems</td>
</tr>
<tr>
<td>DSES-6870 Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Mining Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4810 Computational Intelligence</td>
</tr>
<tr>
<td>DSES-6090 Applied Regression Analysis</td>
</tr>
<tr>
<td>DSES-6200 Design of Experiments</td>
</tr>
<tr>
<td>DSES-6300 Sampling Methods</td>
</tr>
<tr>
<td>DSES-6400 Nonparametric Methods</td>
</tr>
<tr>
<td>DSES-6600 Applied Multivariate Analysis</td>
</tr>
<tr>
<td>DSES-6630 Discrete-Event Simulation</td>
</tr>
<tr>
<td>DSES-6660 Information Technology and Systems for Enterprise Engineering</td>
</tr>
<tr>
<td>DSES-6700 Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Information Systems Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSES-4810 Computational Intelligence</td>
</tr>
<tr>
<td>DSES-6500 Information and Decision Technologies for Industrial and Service Systems</td>
</tr>
<tr>
<td>DSES-6520 Enterprise Database Systems</td>
</tr>
<tr>
<td>DSES-6530 Decision Support and Expert Systems</td>
</tr>
<tr>
<td>DSES-6560 Information Technology and Systems for Enterprise Engineering</td>
</tr>
<tr>
<td>DSES-6620 Discrete-Event Simulation</td>
</tr>
<tr>
<td>DSES-6870 Introduction to Neural Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial Engineering Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4200 Mathematical Analysis I</td>
</tr>
<tr>
<td>MGMT-4370 Risk Management</td>
</tr>
<tr>
<td>MGMT-6320 Investment Analysis I</td>
</tr>
<tr>
<td>MGMT-6330 Investment Analysis II</td>
</tr>
<tr>
<td>MGMT-6340 Financial Markets and Institutions</td>
</tr>
<tr>
<td>DSES-6010 Applied Regression Analysis</td>
</tr>
<tr>
<td>DSES-6060 Applied Multivariate Analysis</td>
</tr>
<tr>
<td>DSES-6100 Time Series Analysis</td>
</tr>
<tr>
<td>DSES-6130 Statistical Computing</td>
</tr>
</tbody>
</table>
Doctoral Programs

Students working toward the Ph.D. in DSES may choose to major in industrial engineering, information systems, manufacturing systems engineering, operations research, or statistics. Advanced research and a dissertation in the chosen field are required in the doctoral program. In addition, Ph.D. students must complete the following:

- Institution requirements established by the Office of Graduate Education.
- Seminar in DSES research: Doctoral students must complete DSES-6900 during the fall semester of the first academic year of residency. This course is intended to introduce the student to the research environment at Rensselaer and to provide background on the process of doctoral research in DSES. Another intent of the course is to develop the student’s communication skills.
- Doctoral qualifying examination: Each student must take an oral examination covering the core areas of DSES. The basis for this examination includes DSES-4530, DSES-4750, DSES-4760, DSES-4770, and DSES-6500 or their equivalents. This examination is normally taken at the end of the second semester of residency. A more detailed description of this and other required examinations is available from the DSES doctoral program director.
- Doctoral area and advanced seminar requirement: Doctoral students must register for and complete DSES-6910 during the fall semester of the second academic year of residency. This seminar reviews methods for undertaking DSES research and requires students to prepare a research paper under the guidance of a faculty adviser. This requirement also includes course work in a selected major area. See the DSES doctoral program director for detailed documentation of DSES doctoral area requirements.
- Doctoral candidacy examination: Each student must take an oral candidacy examination after passing the DSES area requirement but before completing 75 credit hours of graduate work. This examination tests the candidate’s background for the proposed research, appropriateness of the thesis research, and the ability of the candidate to successfully complete the research. The thesis research proposal must contain at least one result that meets journal publishing standards.
- Doctoral dissertation and defense: Each student must write a doctoral thesis and give a formal oral public defense.

Apart from the seminar and advanced seminar in DSES research, doctoral area course requirements, and equivalent course material for the doctoral qualifying examination, there are no formal course requirements for the doctoral degree. However, the student is expected to develop in-depth knowledge in his/her dissertation area through appropriate course work, as well as supervised research. A plan of study is required, which must be approved by the thesis adviser and the DSES doctoral program director. Representative programs of study are available from the DSES doctoral program director.

Course Descriptions

Courses directly related to all Decision Sciences and Engineering Systems curricula are described in the Course Description section of this catalog under the department code DSES.
Electrical, Computer, and Systems Engineering

Chair: Kenneth A. Connor
Curriculum Chair: A. Bruce Carlson
Director of Master's Programs: Yannick L. LeCoz
Director of Doctoral Programs: Alan A. Desrochers
Department Home Page: http://www.ecse.rpi.edu/

Electrical, computer, and systems engineers have long been at the forefront of new discoveries and their integration into advanced design and engineering methodologies. Inventions in areas such as integrated electronics and optical devices stimulate innovations in computers, control, and communications. New systems theory and mathematical techniques are then needed for analysis and design work.

As a broad-based department, Electrical, Computer, and Systems Engineering (ECSE) offers several advantages for undergraduate and graduate study. One is the ability to attack the many facets of modern problems that cut across disciplinary lines. Another is the flexibility for students to embark on individually tailored programs and for the department to launch new areas of research.

The department offers programs of study leading to bachelors, master’s, and doctoral degrees in electric power engineering, electrical engineering, and computer and systems engineering. Each curriculum is sufficiently flexible to accommodate a wide range of interests. The curriculum the student selects is determined by his or her specific interests and, in some cases, by directions within a field of interest.

Research and Innovation Initiatives

Communications, Information, and Signal Processing

Advanced study and research in this field deals with the encoding, transmission, retrieval, and interpretation of information. Students may pursue programs of study strong in mathematical foundations, or oriented more toward hardware and practical implementation, or a combination of both.

Communications research focuses on the transmission of information over wireless, optical, and wire channels. Link level concerns, such as modulation and coding, as well as local and wide area networks are considered. Two of the fundamental subdisciplines emphasized are statistical communications and telecommunications. The former considers special types of systems in different environments, typified by random signals in random channels, as in space communication. The latter includes the hardware and societal demands of telephone, wireless communications, cable television, communications networks (including ATM and ISDN), and other systems.

The area of information processing is concerned primarily with the theory and engineering design associated with interpreting and manipulating received data, primarily in discrete form. Major research topics include information theory, including rate distortion theory, along with the coding and compression of speech, image, and video signals. A quantitative understanding of the nature and meaning of information provides a theoretical foundation. A special research emphasis at Rensselaer is the application of image transmission and interpretation techniques to pattern recognition, image processing, digital video, and speech recognition.

Signal processing considers the application of digital processing techniques to problems encountered in many areas, including biomedical instrumentation, control systems, and audio processing.
Special laboratories are available for speech processing, video and image processing, networking and communications.

**Computer Networks**

Research focal areas in computer networking include network management, traffic management, congestion control, traffic engineering, quality-of-service (QoS) architectures, multimedia networking, network modeling, measurement, and performance analysis. The application areas include wired, wireless, ad-hoc, satellite networks, and pervasive computing. The networking group also participates in interdisciplinary research in control theory, economics, scalable simulation technologies, and video compression.

As world networks get increasingly complex, the need for automated network management and sophisticated traffic management capabilities becomes more urgent. The theoretical foundations for these areas are of immense interest. Moreover, the structure of the Internet in terms of thousands of ISPs demands new economic models and mechanisms to ensure continued investment and growth of Internet services. Network heterogeneity—especially in terms of wired, wireless, ad-hoc, and satellite—demands fundamental research for seamless interconnection. Rensselaer’s modeling subgroup serves all areas in terms of self-similar and advanced stochastic models. Finally, newer applications with QoS capabilities need to be deployed on the Internet and co-exist with the current applications. The computer network group works on all these areas with a mix of analysis, simulation, and experimental tools.

**Computer Vision, Image Processing, Geometry, and Digital Media**

Research in image processing covers a range of technologies and applications. This activity occurs at the Center for Image Processing Research (CIPR), the Center for Subsurface Sensing and Imaging Systems (CenSSIS), and the Center for Next Generation Video (CNGV), as well as the Document Analysis Laboratory (DocLab), Advanced Imaging Systems Laboratory, Computer Vision and Robotics Laboratory, and Intelligent Systems Laboratory.

Research areas include pattern recognition, computer vision, multidimensional and multimodality image analysis, image compression, biotech assay automation, eye tracking, optical scanning systems, artificial intelligence, graphics, computational geometry, and Internet image analysis services.

Application areas include computer-assisted surgery, radiation treatment planning, medical image reconstruction, document image analysis, geographic data analysis, and image analysis aids to neurobiology. Additional application areas are bioinformatics, human fatigue monitoring, human computer interaction, video imagery activity interpretation, decision making under uncertainty, robot localization, robotic devices for automated scoring of assays for the biotechnology industry, and biological multidimensional microscopy.

The work of digital media includes such topics as image processing algorithms and architectures for digital cinema, advanced image compression and decompression algorithms, and methods for indexing video by content. Multimedia work also includes graphics courseware development for the World Wide Web using HTML, Java, PHP, mySQL, and VRML.

**Computer Hardware, Architecture, VLSI and Mixed Signal Design**

The design, implementation, layout, and testing of hardware systems constitute a vital component of computer engineering research. Research areas include multichip packaging concepts, high-frequency package characterization, thermal management, optical interconnections, and packaging reliability. Other topics include advanced concepts in fault tolerant computing, wafer-scale integration, high-speed GaAs RISC engines architectures for VLSI signal processing, and computer-aided design of VLSI for CMOS, bipolar, BiCMOS, and GaAs MESFET circuits. Fabrication and testing facilities are available in the Center for Integrated Electronics.
Control, Robotics, and Automation

Current research projects address both the theory and application of control. Faculty interest in control theory includes adaptive control, large-scale systems, optimization, multivariable control, robust control, nonlinear control, model reduction, and discrete event systems. Design results are applied to robotics, advanced automation systems, flexible manufacturing, human physiology, large space structures, power systems, semiconductor systems, and material processing systems.

In robotics research, the focus is on intelligent robotic systems. Such systems represent a class of autonomous machines that can perform human-like functions with or without human interaction. They are fundamental for activities too hazardous for humans or too distant or complex for remote telemanipulation. This research is instrumental in advancing the theory of intelligent control with applications to systems of robotic arms. A robotic transporter with two-arm manipulative capabilities, stereo vision, and tactile sensing, connected to a Sun workstation network has been developed.

The design of controllers of large-scale systems is highly complex. Research is being performed on the design of low-order, structurally constrained robust controllers using iterative methods and convex programming techniques. Emphasis is also being given to linear and nonlinear model reduction methods. Applications to power systems, aircraft engines, and flexible structures are being considered, together with the development of control-aided design software.

Today, low-cost, highly reliable microcomputers and workstations that can be used for both control systems design and control system synthesis are widely available. As a result, increased emphasis has been placed on the design of implementable digital adaptive control logic that can be used for maintaining uniform qualities in an aircraft or other systems, despite large variations in the parameters that define the system dynamic equations. Such adaptive control algorithms have been developed and applied to a wide range of applications, including robotics, blood pressure control, large flexible systems, and flight control systems.

Discrete event systems theory is an emerging discipline relevant to communication protocols and parallel computing as well as manufacturing control. Petri net and formal language theory are being developed to model, design, analyze, evaluate performance, and control such interconnected systems. Important issues are deadlock avoidance, synchronization, concurrency, resource allocation, and random events. Applications under study are manufacturing automation and integration, and task coordination for cooperating robotic systems.

All dynamic systems are fundamentally nonlinear. The nonlinearity can be either treated as a perturbation of a nominally linear system or directly taken into account in a nonlinear control design. In the first approach, linear control designs have been developed under various performance and robustness specifications. In the second approach, various nonlinear control strategies have been developed based on the Lyapunov theory, optimal control, and predictive control. There are currently various research projects applying these tools to a wide range of applications including vehicles, smart structures with piezoelectric actuators and sensors and shape memory alloy wires, robot position and force control, extrusion, and welding.

Research areas in robotics include sensor fusion, assembly sequence planning, dexterous manipulation, teleoperated and variably autonomous systems, distributed control architectures, and their applications to inspection, maintenance, and servicing operations in hazardous environments. Extensive experimental and computational facilities are available in the New York State Center for Automation Technologies.

In computer-aided design, research is focused on the front end of the manufacturing process, namely product development. The goal is to understand and develop computer-based systems to support initial conceptual design, feature-based design, geometric modeling, and rapid prototyping.
Electric Power and Power Electronics
Current research is concentrated in five principal areas: electric and magnetic field computation, electric transients and switching technology, dielectrics and insulation systems, power system analysis and optimization, and semiconductor power electronics.

The design of equipment to minimize losses, achieve compaction, or better utilize material frequently requires a sound knowledge of the electric and magnetic field configurations involved. Several projects in the recent past have adapted finite element methods to the solution of current problems in large machines. A new approach to digital field computations is being devised, based on techniques used to solve large network problems. The objective is to develop a more efficient, computationally conservative method. In today’s energy-scarce world, there is a great emphasis on building more efficient electrical equipment. Projects are under way in the magnetic fields area to better understand the mechanism of electrical losses in rotating machinery and power transformers, with the ultimate goal of reducing these losses.

Of current interest are electric transients initiated by the switching of power plant auxiliaries and capacitor banks, especially by vacuum switching devices. The modeling of transients in transformer structures could also provide insight into the problems of both design and operation. The techniques being developed are finding application in new areas such as superconducting magnetic energy storage (SMES) and fault current limiting devices. This area of endeavor also includes the fundamental processes of switching large currents and the attendant system interactions.

An electrical insulation system, be it solid, liquid, gaseous, or a combination of these, is an essential part of all power equipment. Current research seeks to better understand the fundamental behavior of insulation under a variety of operating conditions and to develop diagnostic instrumentation. This involves experimentation and computer modeling in the areas of discharge physics, electrostatic phenomena, and high-voltage technology.

Optimization theory is used in the design of electric power systems to obtain high efficiency at minimum cost, particularly for systems that involve distributed generation. This has been extended to include the development of intelligent protective relaying using the department’s system simulator and Electromagnetic Transient Program (EMTP) studies.

With the development of innovative energy sources such as advanced electric machines, fuel cells, and solar photovoltaics, power electronic systems are playing an ever-increasing role at both the source and the load. Issues of power quality and electromagnetic interference (EMI) need to be addressed through careful circuit design, circuit board layout, and EMI resistant communications. Rensselaer has identified this growing area of interest and is currently investigating future solutions to these challenging problems.

With the continual improvement of power semiconductor devices over the last thirty years, it is now possible to convert electrical energy from one form to another efficiently and accurately. Work in this multidisciplinary field requires an understanding of semiconductor devices, circuit theory, signal analysis, analog and digital control, magnetics, and heat transfer. At Rensselaer, these fields are applied to electronic energy conversion and motion control for the electric power and industrial automation industries. Current interests include propulsion systems for electric vehicles, generation systems for wind turbines, the use of artificial intelligence (fuzzy logic, genetic algorithms, and neural networks) in the design and control of electric power conversion and electric machines, and the adaptive control of electric machines.

Microelectronics and Photonics Technology
Advanced study and research includes semiconductor devices for power and high-frequency applications, fabrication of novel semiconductor materials and device structures, and the use and development of computer tools for microelectronics design. Research in association with the Center for Advanced Interconnect
Sciences and Technology (CAIST) focuses on overcoming the strong limits interconnects pose for future developments in VLSI technology.

An extensive clean room in the Center for Integrated Electronics (CIE) is equipped for fabricating silicon-based devices, integrated circuits, and a full complement of equipment for compound semiconductor device processing. Activities in this area have been focused on novel device technology and process development, advanced interconnect processing, and the fabrication of micromechanical structures.

The microelectronics group has several specialized laboratories equipped to meet industrial standards for advanced research techniques. The electronic materials laboratory includes several state-of-the-art bulk crystal growth systems, wafer slicing and chemical mechanical polishing facilities, liquid phase epitaxy system for multilayer hetero-epitaxy growth, and cold wall epitaxial reactors for the growth of single crystal III-V and II-VI semiconductors. Diagnostic equipment available includes a scanning electron microscope with energy dispersive X-ray analysis, a double crystal X-ray diffractometer, a Fourier transform IR spectrometer, a photoluminescence system with visible and UV excitation, a spectroscopic ellipsometer, and a Hall-effect measurement system.

The high-voltage power device laboratory has equipment that can measure semiconductor power devices in wafer and package form up to 5000 V and 25 A. The equipment includes a Sony/Tektronix 370A curve tracer, an HP 4155 parameter analyzer with a high power module, a Velonex High Power Pulse Generator Model 350, a custom high-voltage rectifier and IGBT switching circuits, a 500 MHz digitizing oscilloscope, a Delta 9023 furnace, and a manual probe station with a high-temperature controller and chuck for device testing.

The semiconductor device characterization laboratories are equipped for carrying out comprehensive electrical characterization of semiconductor devices. Automated measurement systems are available for CV and IV measurements and deep level transient spectroscopy. Facilities are available for cryogenic measurements of semiconductor and superconducting devices at liquid nitrogen and helium temperatures. Additional specialized instrumentation has been developed for analyzing the quantum efficiency and spectral response of solar cells and photoconductive materials, and automated reflectance, electroreflectance, and photoreflectance for the characterization of semiconductor surfaces and quantum layers. Also available is a wide-band 35 GHz microwave setup for contactless measurement of electric resistivity, mobility, and excess carrier lifetime in epitaxial layers or bulk wafers. A full complement of microwave equipment is available for high frequency testing, including HP 8510 and 8410 network analyzers, frequency counters, probe stations, and an automated multiprobe system for on-wafer time-domain measurements.

Within the ECSE Department and the Center for Integrated Electronics are numerous Sun workstations with a variety of commercial design and simulation software, presently including Cadence, Mentor, TMA, and Hewlett-Packard software suites. Research programs developing supplemental design tools for modeling integrated circuits, devices, processes, and interconnects have provided unique supplemental capabilities.
Plasma Engineering and Electromagnetics

Plasma engineering and electromagnetics have played fundamental roles in electrical engineering throughout the history of this discipline. Research at Rensselaer in recent years has centered on two general areas—analysis of electromagnetic fields and characterization of plasma media. Project areas include diagnostics for fusion plasmas based on the interaction between energetic particle beams and plasmas, the application of finite element methods to microwave heating of a variety of materials, antenna design, low temperature plasma modification of materials, magnetic levitation, and electric vehicles. Additional microwave projects are described in the section above.

High-temperature plasma research is crucial to the development of a controlled thermonuclear fusion energy source. Rensselaer’s Plasma Dynamics Laboratory has a very active research program on the development of particle beam diagnostic systems for magnetically confined plasma experiments. Specific diagnostic techniques are developed and tested on relatively small-scale experiments in the on-campus laboratory. Techniques are then scaled up and applied on major confinement experiments located at other U.S. universities (e.g., the Universities of Texas and Wisconsin), at U.S. national laboratories (e.g., Oak Ridge National Lab and Lawrence Livermore National Lab), and foreign institutions (e.g., the Japanese National Institute for Fusion Science).

Electromagnetics remains one of the richest sources of problems and opportunities for electrical engineers. In recent years, the availability of powerful analysis tools, such as those based on finite element methods, has greatly enhanced the ability to exploit electromagnetic phenomena for the greater good of society. Issues associated with high power microwave antenna design, material properties assessment for microwave heating applications, noise in electric vehicle design, and processing of waste materials have been addressed.

Faculty*

Professors

Bhat, I.—Ph.D. (Rensselaer Polytechnic Institute); solid state, electronic materials.
Chow, J.H.—P.E., Ph.D. (University of Illinois); large-scale system modeling, multivariable control systems.
Chow, T.P.—Ph.D. (Rensselaer Polytechnic Institute); semiconductor device physics and processing technology, integrated circuits.
Connor, K.A.—Ph.D. (Polytechnic Institute of New York); electromagnetic theory, wave propagation, plasmas for fusion research and industrial applications, finite element methods.
Degeneff, R.C.—P.E., D.Eng. (Rensselaer Polytechnic Institute); transient voltages in electrical machines and transformers, HVDC system design and electric utility system planning.
Desrochers, A.A.—Ph.D. (Purdue University); discrete event dynamic systems, robotics, automated manufacturing systems control.
Gerhardt, L.A.—Ph.D. (State University of New York, Buffalo); communication systems, digital voice and image processing, adaptive systems and pattern recognition, integrated manufacturing.
Gutmann, R.J.—Ph.D. (Rensselaer Polytechnic Institute); solid-state devices, microwave techniques, and interconnection technology.
Jennings, W.C.—Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, electronics manufacturing, multimedia educational materials.
McDonald, J.F.—Ph.D. (Yale University); communication theory, coding and switching theory, computer architecture, integrated circuit design, high frequency packaging, digital signal processing.
Nagy, G.—Ph.D. (Cornell University); pattern recognition, document-image analysis, optical character recognition, geometric computation, computer-mediated learning, computer vision.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Nelson, J.K. — C.Eng., Ph.D. (University of London); dielectrics and insulation systems, computer-based diagnostics, electrostatic phenomena.

Pearlman, W.A. — Ph.D. (Stanford University); information theory and source coding; image, video, and audio compression; digital image and signal processing.

Roysam, B. — D.Sc. (Washington University); intelligent imaging at low SNR, parallel computation, biomedical applications.

Salon, S.J. — P.E., Ph.D. (University of Pittsburgh); machine design, system component modeling and simulation.

Sanderson, A.C. — Ph.D. (Carnegie Mellon University); robotics, knowledge-based systems, computer vision.

Schubert, E.F. — Ph.D. (University of Stuttgart); compound semiconductor devices and materials, light emitting diodes, heterobipolar transistors, semiconductor device physics, solid state lighting.

Shur, M.S. — D.Sc. (Ioffe Institute); semiconductor materials and devices, integrated circuit simulation, characterization and design.

Tien, J.M. — Ph.D. (Massachusetts Institute of Technology); systems modeling, queuing theory, public policy and decision analysis, computer performance evaluation, information systems, expert systems, computational cybernetics.

Vastola, K.S. — Ph.D. (University of Illinois); computer and communication networks.

Wen, J.T. — Ph.D. (Rensselaer Polytechnic Institute); nonlinear control, robot control, flexible structures control, deformation processes control.

Woods, J.W. — Ph.D. (Massachusetts Institute of Technology); digital signal processing, image processing, digital image and video compression.

Wozny, M.J. — Ph.D. (University of Arizona); computer graphics, computer-aided design, digital simulation, rapid prototyping systems.

Zhang, X.-C. — Ph.D. (Brown University); ultrashort optical pulse spectroscopy, terahertz lasers.

Associate Professors

Franklin, W.R. — Ph.D. (Harvard University); computational geometry, graphics and CAD applications, large geometric databases, geographic information systems, terrain visibility and compression.

Kalyanaraman, S. — Ph.D. (Ohio State University); ATM and Internet traffic management, multimedia networking, IP telephony, performance analysis, Internet pricing.

LeCoz, Y.L. — Ph.D. (Massachusetts Institute of Technology); numerical methods, random-walk algorithms for thermal and electromagnetic analysis of IC interconnects, quantum theory of semiconductor heterojunctions.

Saulnier, G.J. — Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing.

Schoch, P.M. — Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, instrumentation, engineering education.

Stephanou, H.E. — Ph.D. (Purdue University); multifingered robot hands, machine intelligence, neural networks, sensor fusion.

Sun, J. — Ph.D. (University of Paderborn); power electronics and energy systems.

Assistant Professors

Abouzeid, A.A. — Ph.D. (University of Washington); packet networks.

Arcak, M. — Ph.D. (University of California, Santa Barbara); design and analysis of nonlinear control systems, adaptive control, applications to mechanical systems.
Dutta, P.S.—Ph.D. (Indian Institute of Science); compound semiconductor materials and devices, crystal growth and substrate engineering, semiconductor quantum dots and nano-particles, photovoltaics, optoelectronics and microelectronics technologies.

Huang, W.—Ph.D. (Carnegie Mellon University); robotic manipulation, mobile robotics.

Ji, Q.—Ph.D. (University of Washington); computer vision, image processing, pattern recognition, robotics.

Kar, K.—Ph.D. (University of Maryland); routing and traffic management in computer networks, congestion control and fair resource allocation, ad-hoc and sensor networks.

Mercado, A.V.—Ph.D. (University of Maryland); wireless communication.

Radke, R.J.—Ph.D. (Princeton University); image and video processing.

Sikdar, B.—Ph.D. (Rensselaer Polytechnic Institute); computer networks.

Yazici, B.—Ph.D. (Purdue University); inverse problems in biomedical imaging, tomography, diffuse optical tomography, biomedical optics, free space optical communications, ultrasonics, statistical pattern recognition theory and application.

Zhang, T.—Ph.D. (University of Minnesota); VLSI signal processing, error-correcting coding.

Clinical Professors

Carlson, A.B.—Ph.D. (Stanford University); communication systems, circuits and electronics, educational methods, social context of engineering.

Murtuza, S.—Ph.D. (Purdue University); engineering education.

Research Professor

Kliman, G.B.—Ph.D. (Massachusetts Institute of Technology); electric motors and drives.

Research Associate Professors

Lu, J.—Ph.D. (Technical University of Munich); electronic materials.

Millard, D.L.—Ph.D. (Rensselaer Polytechnic Institute); microelectronics design and manufacturing, nondestructive testing and evaluation, instrumentation systems, multimedia development.

Research Assistant Professors

Azimi-Sadjadi, B.—Ph.D. (University of Maryland); stochastic systems, control, communication.

Bonneau, R.J.—Ph.D. (Columbia University); wireless communication, image and video compression, radar tracking and imaging.

Demers, D.—Ph.D. (Rensselaer Polytechnic Institute); fusion plasmas, plasma diagnostics.

Gessmann, T.—Ph.D. (University of Stuttgart); condensed matter, wide bandgap semiconductors.

Adjunct Faculty


Berry, G.T.—PE, M.E. (Harvard University); power system operation.

Blake, J.P.—M.S. (Union College); software engineering.

Bonissone, PP.—Ph.D. (University of California, Berkeley); theory of fuzzy sets.

Bonner, S.J.—Ph.D. (Rensselaer Polytechnic Institute); robotics.

Caola, R.J.—M.E. (Rensselaer Polytechnic Institute); protective relaying.

Citriniti, T.D.—M.S. (Rensselaer Polytechnic Institute); computer graphics and visualization.

Goldschmidt, D.E.—M.S. (Rensselaer Polytechnic Institute); software engineering.

Hershey, J.E.—Ph.D. (Oklahoma State University); communication systems, cryptograph, intellectual property management.

Johansen, R.B.—M.S.E. (Union College); computer languages, array signal processing, precision control of micromechanical systems.
Kraft, R.P.—Ph.D. (Rensselaer Polytechnic Institute); digital control and manufacturing systems.

Marwali, M.K.—Ph.D. (Illinois Institute of Technology); power transmission and generators.

Merrill, H.M.—P.E., Ph.D. (Massachusetts Institute of Technology); economic operation, planning and control of power systems.

Michael, J.D.—Ph.D. (Rensselaer Polytechnic Institute); plasma diagnostics, instrumentation, low pressure discharge modeling, laser diagnostics, novel light sources.

Prabhakara, E.S.—Ph.D. (Purdue University); power systems.

Reichard, M.L.—P.E., M.E. (Pennsylvania State University); industrial power systems.

Sivasubramanian, K.—Ph.D. (Rensselaer Polytechnic Institute); electromagnetics, machines.

Spang, H.A., III—D.Eng. (Yale University); control systems, theory and implementation.

Thomenius, K.D.—Ph.D. (Rutgers University); imaging science.

Torrey, D.A.—P.E., Ph.D. (Massachusetts Institute of Technology); semiconductor power electronics, electric machinery.

Yuksel, M.—Ph.D. (Rensselaer Polytechnic Institute); computer networks, Internet pricing, routing in wireless networks, large-scale network simulation.

Emeritus Faculty

Borrego, J.M.—P.E., Sc.D. (Massachusetts Institute of Technology); semiconductor device physics and characterization, solar cells, application of microwaves.

Close, C.M.—Ph.D. (Rensselaer Polytechnic Institute); network analysis and synthesis, control systems.

Das, P.K.—Ph.D. (University of Calcutta); microwave acoustics, solid-state devices, integrated circuits.

DiCesare, F.—Ph.D. (Carnegie Mellon University); discrete event systems, Petri net theory and applications manufacturing automation and integration, traffic control.

Frederick, D.K.—Ph.D. (Stanford University); automatic control, process modeling and control, computer simulation.

Ghandhi, S.K.—Ph.D. (University of Illinois); solid-state materials and devices, integrated circuits, device technology and electronic circuits.

Greenwood, A.N.—Ph.D. (University of Leeds); electrical transients, interrupting devices.

Hickok, R.L., Jr.—Ph.D. (Rensselaer Polytechnic Institute); gaseous electronics, plasmas, energy conversion.

Kelley, R.B.—Ph.D. (University of California, Los Angeles); methods to give machines smart behaviors, sensor-based automation/robotic systems, teaching methods.


Rose, K.—Ph.D. (University of Illinois); semiconductor and superconductor materials and processing, VLSI design and testing.

Saridis, G.N.—Ph.D. (Purdue University); intelligent control systems, pattern recognition, computer systems, robotics, prostheses.

Savic, M.—Eng.Sc.D. (University of Belgrade); signal processing, biomedical electronics, electronics.

Saxena, A.N.—Ph.D. (Stanford University); solid-state materials, devices, integrated circuits, and advanced technologies.

Senior Research Engineer

Schatz, J.G.—A.A.S. (Hudson Valley Community College); vacuum and electronic systems.
Undergraduate Programs

Objectives of the Undergraduate Curriculum

The objectives of the programs in Electrical, Computer, and Systems Engineering are:

- To provide students with a foundation in mathematics, science, and engineering
- To provide students with the technical background needed for the practice of or for graduate study in, Electrical, Computer and Systems, or Electric Power Engineering. This background differs between the programs by having:
  a. an emphasis on applied electro-physics, including electronics, electromagnetics and semiconductors, for Electrical Engineering, or
  b. an emphasis on applied computer science, including data structures, computer architecture and software engineering, for Computer and Systems Engineering, or
  c. an emphasis on electric power systems, including electromagnetics, electromechanics, and power semiconductor applications for Electric Power Engineering
- To prepare students to function in a professional environment, including the development of communication, leadership, and teamwork skills, the awareness of professional and ethical responsibility, and the preparation for life-long learning
- To provide students with a broad education including exposure to the humanities and social sciences
- To provide a learning environment that includes innovative pedagogical approaches and the access to current instrumentation and software tools

Baccalaureate Programs

Within this department, students may obtain the Bachelor of Science degree in three disciplines, electrical engineering, computer and systems engineering, or electric power engineering. The department also encourages students to consider graduate study in any of these three curricula. A professional program option, which leads to both the B.S. and M.Eng. degree, is also open to qualified students.

Engineering design is introduced and developed in the required courses ENGR-2050, ENGR-2350, and ECSE-2610, and in various electives. These courses set the stage for capstone design experience in the design elective, a writing-intensive course that satisfies the Institute writing requirements.

The following program descriptions indicate course schedules for students who select any of the three ECSE disciplines as their chosen field of study. However, various arrangements can be made with the help of an adviser. In all cases, adviser approval of individual plans of study is necessary to ensure satisfaction of departmental and accreditation requirements. The adviser must also approve in writing any exceptions to the courses specified in the descriptions below.

All three of the ECSE curricula require completion of a minimum of 128 credit hours. Within all of these program areas, the Pass/No Credit option may be used only for humanities and social sciences electives (up to a maximum of six credits) or free electives. All other courses used to satisfy the degree requirements must be taken on a graded basis.
**Electrical Engineering Curriculum**

Traditionally the largest and most diverse in all of engineering, this curriculum offers courses with various degrees of emphasis on theory, design, experimental work, and computer simulation. Subject matter ranges from semiconductors and electromagnetics to circuits and electronics, and to large-scale control, computer, communication, and information processing systems.

### First Year
#### Fall
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1310</td>
<td>Intro. to Eng. Electronics</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Spring
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD ¹</td>
<td>1</td>
</tr>
<tr>
<td>MATH-1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
</tbody>
</table>

### Second Year
#### Fall
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Spring
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2010</td>
<td>Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
<td>4</td>
</tr>
</tbody>
</table>

### Third Year
#### Fall
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2050</td>
<td>Analog Electronics or</td>
<td></td>
</tr>
<tr>
<td>ECSE-2060</td>
<td>Digital Electronics</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Multidisciplinary Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Spring
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2100</td>
<td>Fields and Waves I</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2210</td>
<td>Microelectronics Technology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Applied Mathematics Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective ³</td>
<td>3–4</td>
</tr>
</tbody>
</table>

### Fourth Year
#### Fall
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-4500</td>
<td>Probability for Engineering Applications ¹</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development II</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Spring
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Laboratory Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Design Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Restricted Electives (3)</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Free Electives (2 or 3)</td>
<td>8–9</td>
</tr>
</tbody>
</table>

¹ May be taken either term.
² May be replaced by ENGR-1300.
³ Students entering this program in the fourth term should take CSCI-1100 in the spring, deferring ECSE-2610.
⁴ The free electives must total at least 12 credits.
⁵ This course will be fulfilled from a list published at the start of each semester.
⁶ May be taken in the third year.
Humanities or Social Sciences Electives
In this area, electives are based on the Institute and School of Engineering requirements. Additionally, at least one course must be selected from the list posted on the ECSE home page. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Restricted Electives
Any course with the designation EPOW or ECSE. Additionally, one restricted elective may be a course numbered ENGR-2xxx or ENGR-4xxx.

**Laboratory Electives**
- ENGR-4710 Advanced Manufacturing Laboratory I (Fall)
- EPOW-4030 Electric Power Engineering Laboratory (Spring)
- ECSE-4220 VLSI Design (Fall)
- ECSE-4690 Experimental Networking (Fall)
- ECSE-4760 Computer Applications Laboratory (Spring)
- ECSE-4770 Computer Hardware Design (Fall)

**Design Electives**
- ECSE-4120 Electronic Engineering Design (Spring)
- ECSE-4180 Microwave Circuit Design (Spring)
- ECSE-4260 Physical Design in Microelectronics (Spring)
- ECSE-4560 Signal Processing Design (Spring)
- ECSE-4980 Senior Design Project (Fall or Spring)
- ECSE-6700 Advanced Computer Hardware Design (Spring)
- ECSE-4961 ECSE Design (Fall and Spring)
- ECSE-4962 Control Systems Design (Spring)
- ENGR-4060 Inventors Studio (Fall and Spring)

**Multidisciplinary Electives**
- ENGR-1600 Materials Science for Engineers
- ENGR-2090 Engineering Dynamics
- ENGR-2250 Thermal and Fluids Engineering I
- ENGR-2530 Strength of Materials

**Applied Mathematics Electives**
- CSCI-2400 Models of Computation
- CSCI-4020 Computer Algorithms
- CSCI-4260/MATH-4150 Graph Theory
- CSCI-4260/MATH-2010 Multivariable Calculus and Matrix Algebra
- CSCI-4260/MATH-2800 Introduction to Discrete Structures
- CSCI-4260/MATH-4700 Foundations of Applied Mathematics

**Concentrations**
Two ECSE 4000/6000-level electives, not including the design elective, must form a Technical Concentration.
Computer and Systems Engineering Curriculum
This field is one of the fastest-growing branches of engineering. Strong course sequences in software, hardware, and systems engineering are available. Students consider the digital computer as a system in itself, as a tool for modeling and design, and as an online element within a real-time system. There is the flexibility to study in depth automatic control, communications, or information processing, in addition to computer software, systems, and hardware.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis</td>
</tr>
<tr>
<td>ENGR-1310</td>
<td>Intro. to Eng. Electronics</td>
</tr>
<tr>
<td>MATH-1020</td>
<td>Calculus II</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II</td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control</td>
</tr>
<tr>
<td>ECSE-2610</td>
<td>Computer Components and Operations</td>
</tr>
<tr>
<td>CSCI-2300</td>
<td>Data Structures &amp; Algorithms</td>
</tr>
<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2660</td>
<td>Computer Architecture, Networks, and Operating Systems</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design</td>
</tr>
<tr>
<td>ECSE-2010</td>
<td>Electric Circuits</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Multidisciplinary Elective</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2410</td>
<td>Signals and Systems</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Applied Mathematics Elective</td>
</tr>
<tr>
<td>CSCI-2300</td>
<td>Free Elective</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4500</td>
</tr>
<tr>
<td>ENGR-4010</td>
</tr>
<tr>
<td>CSCI-1200</td>
</tr>
<tr>
<td>CSCI-1200</td>
</tr>
<tr>
<td>CSCI-1200</td>
</tr>
<tr>
<td>CSCI-1200</td>
</tr>
</tbody>
</table>

---

1. May be taken either term
2. May be replaced by ENGR-1300
3. Students entering this program in the fourth term should take CSCI-1100 and ENGR-2350 in the spring deferring ECSE-2610, ECSE-2660, CSCI-1200, and CSCI-2300.
4. The free electives must total at least 12 credits.
5. This course will be fulfilled from a list published at the start of each semester.
6. May be taken in the third year.
Humanities or Social Sciences Electives
In this area, electives are based on the Institute and School of Engineering requirements. Additionally, at least one course must be selected from the list posted on the ECSE home page. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Restricted Electives
Any course with the designation ECSE or CSCI. Additionally, one restricted elective may be a course numbered ENGR-2xxx or ENGR-4xxx.

Software Engineering Electives
ECSE-4690 Experimental Networking (Fall)
ECSE-4750 Computer Graphics (Fall or Spring)
ECSE-6770 Software Engineering I (Fall)
CSCI-4380 Database Systems (Fall or Spring)
CSCI-4440 Software Design and Documentation (Fall or Spring)
CSCI-4600 The Human-Computer Interface (Spring)

Multidisciplinary Electives
ENGR-1600 Materials Science for Engineers
ENGR-2090 Engineering Dynamics
ENGR-2250 Thermal and Fluids Engineering
ENGR-2530 Strength of Materials

Applied Mathematics Electives
CSCI-2400 Models of Computation
CSCI-4020 Computer Algorithms
CSCI-4260/ MATH-4150 Graph Theory
MATH-2010 Multivariable Calculus and Matrix Algebra
MATH-2800 Introduction to Discrete Structures
MATH-4700 Foundations of Applied Mathematics

Design Electives
ECSE-4962 Control Systems Design (Spring)
ECSE-4960 Signal Processing Design (Spring)
ECSE-4790 Microprocessor Systems (Fall)
ECSE-4980 Senior Design Project (Fall or Spring)
ECSE-6700 Advanced Computer Hardware Design (Spring)
ECSE-4961 ECSE Design (Fall and Spring)
ENGR-4060 Inventors Studio (Fall and Spring)

Concentrations
Two ECSE 4000/6000-level electives, not including the design elective, must form a Technical Concentration.

Electric Power Engineering Curriculum
The traditional place for electric power studies in a university is in the electrical engineering program, where the power option is offered as one of several concentrations. At Rensselaer, electric power is a separate degree program with its own faculty. It maintains strong ties to industry and is dedicated to preparing students for careers in power generation, delivery, or equipment; power electronics applied to drives and power conditioning; or at the intersection of electric power, economics, and management.

The vital role that energy plays in our lives has become increasingly evident in recent years. Society as we know it cannot function without an abundant supply of energy. It turns the wheels of industry and agriculture; it provides transportation; it supplies many of our domestic and recreational needs. There is continuing controversy over the primary source of the energy, but there is widespread agreement that electrical energy, because of its ease of transformation to and from other energy forms and its ease of transmission, distribution, and utilization, is ideal. It is expected that electrical energy will constitute an increasing portion of the total energy used.

To keep pace with expanding needs through the development of ever more sophisticated systems requires the technical talent, scientific knowledge, mature judgment, and visionary innovation of the best engi-
neering minds of this generation. The electric power engineering program at Rensselaer is dedicated to meeting this need in generation, delivery, and utilization in an increasingly competitive environment. Study at Rensselaer is supported by the power industry, which the program serves. In particular, the ECSE Department operates a Grainger Scholar program under the auspices of the Grainger Foundation for well-qualified U.S. students.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300 Chemistry Principles for Engineers</td>
<td>4</td>
<td>ENGR-1600 Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis</td>
<td>4</td>
<td>PHYS-1160 Physics I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1200 Eng. Graphics and CAD</td>
<td>1</td>
<td>ENGR-1300 Engineering Processes</td>
<td>1</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400 Introduction to Differential Equations</td>
<td>4</td>
<td>ECSE-2010 Electric Circuits</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200 Physics II</td>
<td>4</td>
<td>ENGR-4050 Modeling and Control of Dynamic Systems</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2050 Intro. to Engineering Design</td>
<td>4</td>
<td>ENGR-2600 Modeling and Analysis of Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>CSCI-1190 Beginning C Programming for Engineers</td>
<td>1</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4300 Electronic Instrumentation</td>
<td>4</td>
<td>ECSE-2410 Signals and Systems</td>
<td>4</td>
</tr>
<tr>
<td>ECSE-2100 Fields and Waves I</td>
<td>4</td>
<td>EPOW-4020 Electromechanics</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-2250 Thermal and Fluids Engineering I</td>
<td>4</td>
<td>ENGR-2350 Embedded Control</td>
<td>4</td>
</tr>
<tr>
<td>EPOW-4010 Power Engineering Fundamentals</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Professional Development II</td>
<td>2</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPOW-4080 Semiconductor Power Electronics</td>
<td>3</td>
<td>EPOW-4850 Electric Power Eng. Design</td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective</td>
<td>3</td>
<td>EPOW-4030 EPE Laboratory</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Technical Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ENGR-4010 Professional Development III</td>
<td>1</td>
</tr>
</tbody>
</table>

1. There should be a total of 20 credit hours of H&SS electives.
2. These required courses may be taken in any order.
3. May be replaced by ENGR-1310.
4. Any course in engineering or science that is at the 2000 level or higher.
5. Can be taken in either semester during senior year.
6. This course will be fulfilled from a list published at the start of each semester.
Humanities or Social Sciences Electives
In this area, electives are based on the Institute and School of Engineering requirements. Additionally, at least one course must be selected from the list posted on the ECSE home page. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Concentration in Power Electronics Systems
The concentration in Power Electronics Systems is open to all students in Electric Power Engineering. Fulfillment of the concentration will be recognized by the department and consists of both the following courses:

- EPOW-4080 Semiconductor Power Electronics Systems
- EPOW-4850 Electric Power Engineering Design (with Power Electronics emphasis)

and one of the following:
- ECSE-4250 Integrated Circuit Processes and Design
- ECSE-4290 Electronic Packaging
- MANE-4490 Mechatronics
- MANE-4250 Mechatronic System Design

Minor Programs
Minors in any of the three ECSE curricula are open to undergraduates not majoring in any of these disciplines. The corresponding curriculum chair must approve all minors.

In Electrical Engineering, the minor consists of:

- ECSE-2010 Electric Circuits ................................. 4
- ECSE-2410 Signals and Systems ............................. 4
- ECSE-2610 Computer Components and Operations ........................................ 4
- Approved ECSE elective .............................. 3–4

In Computer and Systems Engineering, the minor consists of:

- ECSE-2010 Electric Circuits ................................. 4
- ECSE-2610 Computer Components and Operations ........................................ 4
- ECSE-2660 Computer Architecture, Networks, and Operating Systems ................. 4
- Approved ECSE elective .............................. 3–4

In Electric Power Engineering, the minor consists of:

- ECSE-2010 Electric Circuits ................................. 4
- ECSE-2050 Analog Electronics or ENGR-4300 Electronic Instrumentation ................. 4
- ECSE-2100 Fields and Waves .................................. 4
- EPOW-4020 Electromechanics ............................. 4
- EPOW-4010 Power Engineering Fundamentals or EPOW-4080 Semiconductor Power Electronics ......... 4

Dual Major Programs
These programs lead to a single baccalaureate degree embracing two fields. Special programs that can be completed in eight terms have been devised for:

- Electrical engineering and applied physics
- Electrical engineering and computer and systems engineering
- Electrical engineering and electric power engineering
- Computer and systems engineering and computer science

Detailed information about these programs is available in the department curriculum office.
Professional Programs
ECSE students following the Electric Power Engineering Program may follow this option to complete both the B.S. and M.S. degrees. In this case, the fourth year follows closely the outline for the last year of the baccalaureate program. However, in choosing electives the student should bear in mind that the following courses must be taken at some time prior to or during the professional program:

ENGR-4760 Engineering Economics
Mathematics elective at 4000 level or higher

The following 4000-level courses (or their equivalents) can be used to satisfy the degree’s mathematics course requirement:
MATH-4600 Advanced Calculus
MATH-4300 Intro. to Complex Variables: Theory and Applications
MATH-4500 Methods of Partial Differential Equations of Mathematical Physics
MATH-4700 Foundations of Applied Mathematics

The typical curricula for the remainder of the program is as follows:

Fifth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPOW-6810</td>
<td>Power Engineering Analysis ..........3</td>
<td>EPOW-6870</td>
<td>Mechanical Aspects of Electric Power Apparatus ..........3</td>
</tr>
<tr>
<td></td>
<td>Selected Power Courses 1 ..........3</td>
<td></td>
<td>Selected Power Courses 1 ..........3</td>
</tr>
<tr>
<td></td>
<td>Electives ..........6</td>
<td></td>
<td>Electives ..........6</td>
</tr>
</tbody>
</table>

A student wishing to qualify for a B.S. degree by the end of the first year of professional school studies must complete the humanities and social sciences core requirement during the first year of the professional program.

Special Undergraduate Opportunities
ECSE offers a couple of special programs for highly qualified students. These include:

The Undergraduate Honors program
This program for outstanding undergraduates in electrical engineering or computer and systems engineering introduces research as a professional activity. All participants attend the ECSE Honors Seminar during their sophomore or junior year. Students also participate in at least one research project. An honors faculty adviser is assigned with whom special academic programs are developed that reflect the capabilities and interests of the exceptional student. Applications are accepted during a student’s third semester or thereafter. Forms are available from the department curriculum office.

1 At least two courses must be selected from the following:

EPOW-6820 Power Quality (Spring)
EPOW-6880 Utility as a Business (Spring or Summer)
EPOW-6830 Protective Relaying (Fall; offered on availability of instructor)
EPOW-6840 Power Generation Operation and Control (Spring)
EPOW-6960 Topics in Electric Power Engineering (Spring or Summer)
EPOW-6860 Surge Phenomena in Electric Power Engineering (Fall)
ENVE-4400 Nuclear Power Systems Engineering (Spring)
The Grainger Scholar program
This program is for well-qualified U.S. students in electric power engineering. Through this program, the power industry, under the auspices of the Grainger Foundation, supports study at Rensselaer.

Graduate Programs
The department offers graduate programs leading to the Master of Engineering, Master of Science, Doctor of Philosophy, and Doctor of Engineering in all three of the department curricula. In all cases, particular emphasis is placed on developing a coherent individualized plan of study with the help of a faculty adviser.

Master’s Programs
Both the M.S. and the M.Eng. require 30 credits beyond the bachelor’s degree.

Master of Science
This program is designed to prepare students for research-oriented careers and eventual pursuit of a doctoral degree. A six-credit thesis or project is usually required, but it may be waived for students who can submit a document of previous individual work that demonstrates equivalency in depth and presentation. Waivers are granted by the director of master’s programs and must be replaced with six credit hours of course work.

The M.S. plans of study in electrical engineering and computer and systems engineering must consist of at least 18 credit hours of 6000-level courses and the thesis/project. At least 21 credit hours of ECSE courses must be taken, or up to six of these may be from a related technical area with the approval of the department. Programs that do not include 21 credit hours from ECSE must have prior approval from the director of master’s programs. Students who do not have adequate preparation for their chosen area of specialization may need to take background courses in addition to the 30 credit hour requirement. An information sheet giving the requirements for several areas of specialization is available for all accepted students.

In the electric power engineering curricula, most study and research is of an applied nature, which is recognized in the awarding of the M.Eng. degree. However, courses and research directed more toward basic understanding of physical phenomena, such as the fundamental processes of electrical breakdown in dielectrics, can be pursued. This type of research would lead to the M.S. degree. This avenue also allows students with accredited degrees—not in engineering but perhaps in science—to obtain advanced degrees in the electric power area.

Master of Engineering
This one-year program is designed to prepare graduates for professional careers. Students entering the program typically hold accredited bachelor’s degrees in appropriate branches of engineering. A master’s thesis or project is not required.

The M.Eng. plans of study in electrical engineering and computer and systems engineering consist of at least 18 credit hours in 6000-level courses. In addition, it must include at least 21 credit hours in ECSE courses, or up to six of these may be from a related technical area with the approval of the department. Programs that do not include 21 credit hours from ECSE must have prior approval from the director of master’s programs. Students who do not have adequate preparation for their chosen area of specialization may need to take background courses in addition to the 30 credit hour requirement. An information sheet giving the requirements for several areas of specialization is available for all accepted students.

The electric power engineering M.Eng. degree is a structured program of advanced professional study for the student holding an accredited bachelor’s degree in the field or its equivalent in electrical engineering.
Course listings do not represent requirements except where indicated (see the fifth year requirements listed earlier); they are intended only to guide the student, who is encouraged to develop an individual program in consultation with his or her graduate adviser.

**Doctoral Programs**

Advanced study and research for a Ph.D. or D.Eng. degree is conducted under the guidance of a thesis adviser representing the department. The student formulates an individual plan of study in consultation with the adviser. The doctoral qualifying examination should be taken prior to completing 15 credit hours beyond the master’s degree. A minimum of 60 credit hours beyond the master’s degree, including a dissertation, is required. The department expects the Institute requirements for candidacy and residency to be satisfied.

In the electric power engineering curricula, most study and research is of an applied nature, which is recognized in the awarding of the D.Eng. degree. However, courses and research directed more toward basic understanding of physical phenomena, such as the fundamental processes of electrical breakdown in dielectrics, can be pursued. This type of research would lead to the Ph.D. degree. This avenue also allows students with accredited degrees—not in engineering but perhaps in science—to obtain advanced degrees in the electric power area.

**Special Graduate Opportunities**

In collaboration with the various campus centers and other departments, ECSE sponsors master’s and doctoral program options in manufacturing systems and semiconductor technology. Descriptions of these programs are available upon request.

**Course Descriptions**

Courses directly related to all Electrical, Computer, and Systems Engineering curricula are described in the Course Description section of this catalog under the department codes CSCI, DSES, ECSE, ENVE, EPOW, ITEC, MATH, MATP, MTLE, and PHYS.

**Materials Science and Engineering**

**Chair:** David J. Duquette  
**Undergraduate Advising:** Minoru Tomozawa  
**Graduate Recruiting:** Roger N. Wright  
**Graduate Advising:** Christoph Steinbruchel  
**Department Home Page:** [http://www.eng.rpi.edu/dept/materials/](http://www.eng.rpi.edu/dept/materials/)

Progress in modern technology is often limited by the availability of suitable solid materials. The materials engineer must produce materials to meet the demands of the designers of jet engines and rocket boosters, microelectronic devices, optical components, medical prostheses, and many other products.

The principles that govern the processing and structure of materials to produce optimum mechanical and physical properties and performance are embodied in the materials engineering curriculum. The program is designed to produce engineers and scientists whose degrees represent useful specialization coupled with a broad background in all classes of materials.

Undergraduate students wishing to extend their education can undertake specialized study in a range of fields. These include research in ceramics, polymers, composites, nanostructured materials, high-temper-
nature alloys, solidification, corrosion, deformation processing, welding, high-strength high-modulus materials, biomaterials, electronic materials, surface and molecular kinetics, glass science, and the origin of mechanical and physical properties in many different types of materials. Graduate students, in addition to pursuing classroom courses, conduct research in a variety of areas described below and write their theses based on this research. Extensive laboratories containing modern and sophisticated equipment are available.

For the student who likes to innovate and who wants to apply knowledge to the real problems of a modern technological society, materials science and engineering provides a broad range of exciting opportunities.

**Research and Innovation Initiatives**

**Materials Processing**

Major research programs include fundamental studies of the solidification process and the effect of solidification under reduced gravity on the formation of dendritic structures, and practically oriented programs in the extrusion processing of aluminum alloys. In the latter program, studies of the complex interactions among stress, strain rate, and temperature during forming processes have made it possible to apply advanced software models to the control of metalworking operations. Studies of powder processing have made possible the extrusion processing of composite materials, while research on joining processes has led to synergistic coupling of adhesive bonding and spot welding technology in automotive sheet metal fabrication. New efforts focused on the synthesis, processing, and properties of nanostructured materials are expanding the capabilities of materials engineering and nanotechnology into additional areas including ceramics, metals, polymers, composites, and biomaterials. Novel applications of carbon nanotubes for device and chemical applications are under investigation, along with chemical, electrical, and mechanical isolation engineering using nanocomposites.

**Materials for Microelectronic Systems**

This research concentrates on materials problems associated with the interconnections between integrated circuit elements. Included are the growth of thin films of metals and both polymer and ceramic dielectric materials, the patterning and etching processes necessary for the fabrication of multilayer devices, and the planarization processes necessary for successful device fabrication. Of special note is the program in microelectronics packaging, which addresses the mechanical, electronic, and thermal aspects of device design and fabrication.

**Glasses and Ceramics**

Research efforts focus on factors influencing the useful lifetime of glass components and the effect of environments, especially aqueous environments, on glass failure. In addition to the conventional applications such as windows and bottles, glasses are used as optical components such as optical communication fibers. Specifically, variation of the glass surface structure with time and its influence on glass properties are under investigation. Another emphasis is the development of nonoxide glasses, primarily those based on fluorides, as the transmitting medium in optical fibers for communications purposes.

**High-Performance Composite Materials**

These materials are used in industrial and consumer products due to their exceptional stiffness and strength-to-weight ratios. Applications of composites in the construction industry, such as steel bridge repairs using graphite-epoxy composites, are growing rapidly. Meanwhile, next generation conceptual plans for hybrid electric vehicles are using ceramic composite components for gas turbine engines and
thermal recuperators. Composites research activities at Rensselaer include ceramic, metallic, and polymer matrix composites; micromechanics and modeling of both fabrication processes and materials properties; design with new materials; synthesis of new matrix materials; and all aspects of the fabrication and characterization of composites and composite structures. Of special note is the sailplane program, in which students have designed, fabricated, and tested an all-composite glider, which has now been flying for over seven years. A new project, the composite hybrid electric vehicle, has also been initiated and offers numerous opportunities for both graduate and undergraduate participation.

**Faculty***

**Professors**

Ajayan, P.M.—Ph.D. (Northwestern University); synthesis, structure, and properties of carbon-based nanostructures and nanocomposites; phase transitions in nanoscale materials; electron microscopy.

Baeslack, W.A. III—Ph.D., P.E. (Rensselaer Polytechnic Institute); physical metallurgy; joining of advanced materials (Dean, School of Engineering)

Duquette, D.J.—Ph.D. (Massachusetts Institute of Technology); environmental and surface effects on the mechanical behavior of metals, corrosion, stress corrosion fatigue (Department Head).

Glicksman, M.E.—Ph.D. (Rensselaer Polytechnic Institute); melting and solidification, transport properties of liquid metals, phase transformation kinetics, metallurgy of superconductors (John Tod Horton Professor of Materials Engineering).

Hudson, J.B.—Ph.D. (Rensselaer Polytechnic Institute); adsorption on solid surfaces, structure and reactivity of solids, physics and chemistry of surfaces, nanocrystal growth.

Messler, R.W., Jr.—Ph.D. (Rensselaer Polytechnic Institute); materials in manufacturing, welding.

Moynihan, C.T.—Ph.D. (Princeton University); ionic transport in glass, infrared transmission in glasses and glass ceramics, thermodynamic properties of glasses.

Nalamasu, O.—Ph.D. (University of British Columbia); electronic and photonic polymers, nanopatterning, micro- and nanofabrication, electronic and photonic devices.

Rajan, K.—Sc.D. (Massachusetts Institute of Technology); electron microscopy, electronic materials, thin films and superlattices.

Siegel, R.W.—Ph.D. (University of Illinois); synthesis, processing, structure, and properties of functional nanostructured materials including metals, ceramics, and composites; biomaterials; atomic-scale defects and diffusion in materials (Robert W. Hunt Professor).

Sternstein, S.S.—Ph.D. (Rensselaer Polytechnic Institute); high-performance composites; physical properties of polymers; rubber elasticity theory; fracture, yielding, and craze formation in glassy polymers and composites, viscoelastic properties; swelling in filled elastomers (William Weightman Walker Professor of Polymer Engineering).

Tomozawa, M.—Ph.D. (University of Pennsylvania); electrical properties of glasses, X-ray and light scattering, phase separation, mechanical properties of glasses.

Wright, R.N.—Sc.D. (Massachusetts Institute of Technology); metal forming and fabrication, mechanical behavior of metals.

**Associate Professors**

Schadler, L.S.—Ph.D. (University of Pennsylvania); polymer and glass matrix composites, micromechanical behavior, strains and interface properties, micro-Raman spectroscopy, environmental effects.

Steinbruchel, C.—Ph.D. (University of Minnesota); thin films, electronic materials, plasma processing, ion beam and ultra-high vacuum techniques.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Assistant Professors

Gall, D.—Ph.D. (University of Illinois, Urbana-Champaign); physical properties of thin films and nanostructures; combined theory, modeling and experimentation in thin film technology as applied to electronic structures and properties, transition-metal nitride film growth and characterization.

Keblinski, P.—Ph.D. (Pennsylvania State University); atomic mesoscopic-level computational modeling of interfacial processes; structure-property correlations; interfaces in silicon, diamond and metals; thin film growth; phase separation.

Ozisik, R.—Ph.D. (The University of Akron, Ohio); multiscale simulations of polymers, surface and interface properties of nanoparticles; development and characterization of fuel cells.

Ramanath, G.—Ph.D. (University of Illinois); thin film electronic materials; interconnects, diffusion barriers, low-k dielectrics; characterization of interfacial reactions, kinetics, and mechanisms of microstructure and phase evolution during deposition and annealing; processing self-organized structures for microelectronics applications.

Shima, M.—Ph.D. (University of Maryland); thin film deposition; nano-patterning, structural and magnetic characterization.

Research Professors

Doremus, R.H.—Ph.D. (University of Cambridge), Ph.D. (University of Illinois); glass science, sintering of ceramics, bone implant materials, reactions in fused salts, crystallization, diffusion, optical properties of metals (New York State Science and Technology Foundation Professor of Glass and Ceramics Science).

Hillig, W.B.—Ph.D. (University of Michigan); ceramic and polymer matrix composites, strength of glass, crystal growth.

Lupulescu, A.—Ph.D. (Rensselaer Polytechnic Institute); diffusion, crystal growth (Research Assistant Professor).

Emeritus Faculty

Chung, C.I.—Ph.D. (Rutgers University); polymer processing, polymer melt theology, relaxation behavior in polymer solids.

Ficalora, P.J.—Ph.D. (Pennsylvania State University); kinetics and thermodynamics of heterogeneous reactions, chemisorption effects on electronic materials.

Lenel, F.V.—Ph.D. (University of Heidelberg); powder metallurgy technology, mechanisms of sintering, precipitation and dispersion strengthening mechanisms.

MacCrone, R.J.—D.Phil. (University of Oxford); electric properties of polymers and oxides, polarons, electron paramagnetic resonance and magnetic behavior of glasses, phase transformations, nucleation, electrical properties of thin oxide and nitride films, one-dimensional conductivity.

Murarka, S.P.—Ph.D. (University of Minnesota); Ph.D. (University of Agra); metallization for deep submicron silicon integrated circuits, low temperature and localized processes, thin dielectric films, diffusion and defects (Elaine S. and Jack S. Parker Chair in Engineering).

Nippes, E.F.—P.E., Ph.D. (Rensselaer Polytechnic Institute); physical metallurgy, welding metallurgy.

Stoloff, N.S.—Ph.D. (Columbia University); mechanical behavior of crystals, order-disorder reactions, fracture, stress corrosion.

Manager of Electron Microscopy Facilities

Dove, R.

Manager of Instruction Laboratories

Van Steele, D.

Manager of Metallographic Facilities

Planty, R.
Undergraduate Programs

Objectives of the Undergraduate Curriculum

While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, the Department of Materials Science and Engineering’s baccalaureate program produces students who will:

■ Exhibit general knowledge in all major classes of materials and specialized knowledge in several classes, such as metals, ceramics and glasses, polymers, composites and electronic materials

■ Recognize the interdependence of the structure, properties, processing, and performance of materials and be able to integrate fundamental materials science with analysis of experimental data, laboratory synthesis and processing as well as quantitative modeling

■ Integrate meaningful design experiences within Materials Engineering and in relationship to other engineering disciplines

■ Exhibit a thorough grounding in fundamental mathematics and science and the ability to apply this knowledge in identifying, formulating, and solving real-life engineering problems

■ Be able to put engineering problems, their solutions, and consequences into a societal context

■ Effectively communicate and work in teams

■ Maintain a desire for life-long learning

Baccalaureate Program

The sample curriculum shown below, which results in the B.S. degree in Materials Engineering, requires a minimum of 128 credit hours and completion of the required elective courses that follow.

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis ...........4</td>
<td>ENGR-1300</td>
<td>Eng. Processes ..................................1</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .........................................4</td>
<td>ENGR-1600</td>
<td>Materials Science for Engineers .................4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers ... 4</td>
<td>MATH-1020</td>
<td>Calculus II .......................................4</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200</td>
<td>Physics II........................................4</td>
<td>MTLE-2100</td>
<td>Science Elective ................................4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations .......4</td>
<td>ENGR-2050</td>
<td>Structure of Materials ........................4</td>
</tr>
<tr>
<td>ENGR-2250</td>
<td>Therm./Fluid I ....................................4</td>
<td>ENGR-2050</td>
<td>Intro to Engineering Design ...................4</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Engineering Graphics and CAD ......1</td>
<td>CSNS-1190</td>
<td>Engineers .........................................1</td>
</tr>
</tbody>
</table>
Electives
The following is a list of courses from which the electives indicated above should be selected.

Restricted Elective Options
- ENGR-2530 Strength of Materials
- ENGR-2350 Embedded Control
- ENGR-2090 Engineering Dynamics
- ECSE-2010 Electric Circuits
- ENGR-4300 Electronics Instrumentation

Materials Electives
- MTLE-4030 Glass Science
- MTLE-4050 Intro. to Polymers
- MTLE-4160 Semiconducting Materials
- MTLE-4290 Electronic Packaging
- MTLE-4410 Welding Processes and Metallurgy
- MTLE-4420 Joining of Advanced Materials
- MTLE-4630 Composites Laboratory

Minors Programs
Students not majoring in materials science and engineering may receive a minor in this discipline by completing 15 credit hours of department courses with a MTLE designation.

Graduate Programs
The Department of Materials Science and Engineering offers programs leading to the M.S., M.Eng., and Ph.D. degrees.

Master’s Programs
Both the M.S. and the M.Eng. require completion of a minimum of 30 credit hours.

Master of Science
For the M.S., students must complete 24 credits of course work, with at least 18 credits in materials courses. Three credits each are required in the areas of thermodynamics and kinetics, structure, and mechanical properties. Students who have not taken courses equivalent to undergraduate work at Rensselaer in X-ray diffraction, thermodynamics, mechanical properties, and their area of specialization must take graduate courses in these areas. Six credits of research work leading to an M.S. thesis are also required.

Master of Engineering
At least 21 credits of course work toward the M.Eng. degree must be materials courses. These must include one course each in structure and defects, thermodynamics and kinetics, and mechanical properties. A capstone independent study project is also required.

1 This course will be fulfilled from a list published at the start of each semester.
2 This course can be taken in either semester of senior year.
Doctoral Programs
A minimum of 45 credits in course work is required for the Ph.D. degree in materials engineering. In addition to the course requirements for the M.S. degree, a minor of nine credits in a subject area outside the materials department is required. The student must pass an oral preliminary examination and an oral candidacy examination, as well as the final examination on the Ph.D. thesis.

Course Descriptions
Courses offered by the Department of Materials Science & Engineering are described in the Course Description section of this catalog under the department code MTLE.

Mechanical, Aerospace, and Nuclear Engineering
Chair: John A. Tichy
Director, Mechanical Engineering: John A. Tichy
Director, Aerospace Engineering: Zvi Rusak
Director, Nuclear Engineering and Engineering Physics: Don Steiner
Associate Chair for Graduate Studies: Antoinette Maniatty
Associate Chair for Undergraduate Studies: Henrik J. Hagerup
Department Home Page: www.rpi.edu/dept/mane

Mechanical engineers are engaged in a wide range of activities. At one end of the spectrum, they are concerned with fundamental engineering science, especially energetics and mechanics. At the other end, they are involved with the hardware of various technologies—the design and manufacture of mechanical components and systems. Aerospace engineering is a branch of mechanical engineering with associated technologies that apply not only to aircraft and spacecraft, but to other vehicular systems such as submarines and hydrofoils as well. Nuclear engineering and engineering physics focus on the methods, devices, and systems required for the peaceful use of nuclear technology. While nuclear engineering’s particular emphasis is on nuclear power generation, engineering physics emphasizes the radiation aspect of this technological area.

Research and Innovation Initiatives
Opportunities for research and innovation are delineated below. Opportunities may be theoretical, computational, and/or experimental. The Flexible Manufacturing Center, the Center for Multiphase Research, the New York State Center for Automation Technologies, the Scientific Computation Research Center, the Center for Integrated Electronics, and the Center for Composite Materials and Structures offer additional research opportunities for the department’s undergraduate and graduate students and their faculty advisers.

Aeronautics
Research is conducted into the performance of fixed wing aircraft, rotorcraft, and space vehicles, as well as micro-vehicles. The research is supported by fundamental studies in aerodynamics, advanced propulsion concepts, vehicle dynamics, and design optimization.

Facilities include the 4-by-6-foot subsonic wind tunnel, the transonic and supersonic blow-down wind tunnel, the 70-foot-long shock tube, the hypersonic shock tunnel, and the structures and controls laboratory.
Applied Mechanics/Mechanics of Materials
Applied Mechanics refers to the theoretical foundations of mechanical engineering. Basic research is being performed on diverse topics such as acoustics, fatigue and fracture processes, nonlinear vibrations, and plasticity. Materials of the latest technologies such as composites, microelectronic materials, and carbon nanotubes are studied from the mechanical perspective. The finite element method is a computational approach in modeling material behavior.

Facilities include the mechanics of materials laboratory, the laboratory for noise control research, and the mechanical systems laboratory.

Energy Systems/Multiphase Phenomena and Heat Transfer
Studies are related to energy conversion and the development of mechanical power, convective heat transfer and freezing, electronic cooling, fouling, heat transfer augmentation, mass transfer, computational fluid dynamics and multidimensional effects in multiphase flow, and heat transfer with applications in nuclear, mechanical, thermal, chemical, biomedical and pharmaceutical systems, development of mechanistic models, and computer simulation capabilities.

Facilities include the gas turbine laboratory; the energy systems laboratory; subsonic, transonic, and supersonic wind tunnels; shock tubes and the hypersonic shock tunnel; the heat transfer laboratory; and the laboratory for fouling research. Additional equipment includes various two-phase flow loops and associated instrumentation, laser Doppler anemometer, optical void probes, and the resources of the Center for Multiphase Research.

Mechanical and Nuclear Engineering are both concerned with energy conversion and the development of mechanical power. Issues of heat transfer are important, from a range of large-scale industrial processes, down to the cooling of electronic micro components with extreme power density. Thermal and fluid flow properties are studied by theoretical and computational means (computational fluid dynamics). Multiphase processes are important in problems from drug delivery optimization to nuclear power cooling systems. Facilities include the thermal fluids laboratory; subsonic, transonic, and supersonic wind tunnels; and the heat transfer laboratory. Additional equipment includes various two-phase flow loops and associated instrumentation, laser Doppler anemometer, etc.

Environmental Health Physics and Radiation Dosimetry
Research in this area has diverse applications: the assessment of environmental radioactivity for the nuclear industry; investigations of health physics practices in hospitals; analysis of worker effective doses from external and internal exposures; and optimization of radiation therapy doses in biomedical applications. These problems are studied theoretically by Monte Carlo methods, among several techniques. Facilities include a versatile health physics laboratory and modern nuclear radiation detection and characterization systems.

Manufacturing/Design
Studies revolve around design methodology in general and mechanical engineering design techniques in particular. There are applications in machinery and mechanical systems design, the development of new manufacturing techniques, and operation of manufacturing facilities. Areas of concentration include CAD/CAM, diagnostics and controls, tribology, metrology rapid prototyping, robotics and flexible manufacturing, and system integration. Facilities include the advanced manufacturing laboratory, the design optimization laboratory, the robotics and mechanisms laboratory, and the mechatronics laboratory.

Nuclear Science and Technology
Research involves a wide spectrum of issues crucial to the nuclear industries. Investigations are ongoing
into the interaction of neutrons and other radiation with materials used in nuclear reactors; nuclear data analysis and evaluation; radiation transport studies; conceptual designs of fusion power systems and their engineering, safety, and environmental implications; plasma wall interactions; analysis of reactor accidents and safety studies. Facilities include a versatile 100-Mev electron linear accelerator, time-of-flight and associated instrumentation, a critical reactor facility, a three-dimensional laser Doppler anemometer, and miscellaneous nuclear radiation equipment and computational aids.

**Space Technology**
Research areas include analysis, design, development, and operations required for space exploration and utilization. Research is ongoing in advanced energetics (laser propulsion), structural dynamics and optimization, and crystal growth in space. Facilities include various supersonic wind tunnels, the shock tube, and crystal growth laboratories.

**Faculty***

**Professors**

Crespo da Silva, M.R.M.—Ph.D. (Stanford University); dynamics, nonlinear vibrations, perturbation methods, computerized symbolic manipulation.

Drew, D.A.—Ph.D. (Rensselaer Polytechnic Institute); applied mathematics, fluid mechanics (joint appointment, Mathematics home department).

Dvorak, G.J.—NAE, Ph.D. (Brown University); mechanics of solids, composite materials and structures, fracture and fatigue (William Howard Hart Professor of Mechanics).

Fish, J.—Ph.D. (Northwestern University); computational mechanics, finite element methods, micromechanics, mathematical modeling (joint appointment, Civil Engineering home department).

Gabriele, G.A.—Ph.D. (Purdue University); design automation, design optimization (Vice Provost for Administration, Dean of Undergraduate Education).

Hajela, P.—Ph.D. (Stanford University); optimum design, structural dynamics, aeroelasticity.

Jensen, M.K.—Ph.D., P.E. (Iowa State University); heat transfer, fluid mechanics, energy systems.

Lahey, R.T., Jr.—NAE, Ph.D., (Stanford University); multiphase flow and boiling heat transfer, reactor safety analysis, reactor thermal-hydraulics, applications of chaos theory (jointly with the Chemical Engineering Department; Edward W. Hood Jr. Professor).

Li, C.J.—Ph.D. (University of Wisconsin-Madison); control of manufacturing process and equipment, machine condition monitoring, nonlinear system identification.

Malaviya, B.K.—Ph.D. (Harvard University); fission and fusion reactor physics and technology, biomedical applications, radioactive waste management, pedagogic technology (jointly with Engineering Science).

Ostrogorsky, A.G.—Sc.D. (Massachusetts Institute of Technology); heat transfer and fluid mechanics, solidification, crystal growth (jointly with Materials Science and Engineering Department).

Podowski, M.Z.—Ph.D. (Warsaw University of Technology); two-phase flow and heat transfer, reactor dynamics and safety, system stability, applied mathematics.

Rusak, Z.—D.Sc. (Technion-Israel Institute of Technology); theoretical aerodynamics, fluid mechanics.

Smith, R.N.—Ph.D. (University of California, Berkeley); energy systems.

Shephard, M.S.—Ph.D. (Cornell University); finite element analysis, computer graphics, computer-aided design (jointly with the Civil Engineering Department; Samuel A. Johnson 37 and Elizabeth C. Johnson Professor of Engineering).

Spilker, R.L.—Ph.D. (Massachusetts Institute of Technology); biomechanics, finite element methods (joint appointment, Biomedical Engineering home department).

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Steiner, D.—PhD. (Massachusetts Institute of Technology); nuclear fusion systems, plasma engineering, radiation effects on materials (Institute Professor of Nuclear Engineering).

Tichy, J.A.—Ph.D. (University of Michigan); tribology, non-Newtonian fluid mechanics, rheology.

Tiersten, H.F.—Ph.D., PE. (Columbia University); continuum mechanics, continuum physics, electro-mechanical devices, structures.

Associate Professors

Anderson, K.S.—Ph.D. (Stanford University); multibody dynamics, parallel computing, vehicle dynamics.

Blanchet, T.A.—Ph.D. (Dartmouth College); tribology, solid lubrication, surface science, contact mechanics.

Craig, K.C.—Ph.D. (Columbia University); design, tribology, mechanics, controls (Chair, Engineering Science, and Director, Core Engineering).

Derby, S.J.—Ph.D. (Rensselaer Polytechnic Institute); automation, mechanisms, robotics, design.

Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); fusion engineering, applied chaos theory, neural networks (joint appointment, Decision Sciences and Engineering Systems home department).

Hagerup, H.J.—Ph.D. (Princeton University); viscous flow.

Hirsa, A.—Ph.D. (University of Michigan); fluid mechanics, experimental gas dynamics.

Huang, H.—Ph.D. (University of California, Los Angeles); nanomechanics of materials, thin film deposition, radiation damage, multiscale materials modeling.

Jansen, K.—Ph.D. (Stanford University); computational mechanics, parallel computing, computational fluid dynamics.

Kaminski, D.A.—Ph.D. (Rensselaer Polytechnic Institute); heat transfer, computational fluid mechanics, thermal radiation.

Maniatty, A.M.—Ph.D. (Cornell University); continuum mechanics, mechanics of materials (Clare Boothe Luce Associate Professor).

Messac, A.—Ph.D. (Massachusetts Institute of Technology); optimal design, physical programming, design methodology, structural dynamics.

Myrabo, L.N.—Ph.D. (University of California, San Diego); energy systems, space technology.

Scarton, H.A.—Ph.D. (Carnegie Mellon University); biomechanics, wave phenomena, acoustics, noise control.

Walczyk, D.F.—Ph.D., PE. (Massachusetts Institute of Technology); rapid tooling, environmentally conscious design, machine design.

Xu, G.X.—Ph.D. (Texas A&M University); environmental health physics, health and medical physics, Monte Carlo simulations, anatomical modeling, biomedical use of radiation (jointly with the Biomedical Engineering Department).

Associate Clinical Professor

Steiner, M.W.—Ph.D. (Rensselaer Polytechnic Institute); multidisciplinary design, product architecture, advanced design methods.

Assistant Professors

Borca-Tasciuc, T.—Ph.D. (University of California, Los Angeles); heat transfer and energy conversion, nanotechnology, MEMS.

Castillo, L.—Ph.D. (University at Buffalo); fluid mechanics, turbulent boundary layers.

Danon, Y.—Ph.D. (Rensselaer Polytechnic Institute); nuclear instrumentation and data, accelerator technology and radiation applications, nondestructive testing, neural networks applications.

De, S.—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, multimodal virtual environments, fast computational techniques of MEMS.
Koratkar, N.A.—Ph.D. (University of Maryland at College Park); smart materials and structures, rotorcraft, unsteady aerodynamics.

Peles, Y.—Ph.D. (Technion-Israel Institute of Technology); MEMS fabrication, design and device testing, design and manufacturing of electronic packaging.

Picu, C.R.—Ph.D. (Dartmouth College); mechanics of solids, micro- and nano-mechanics of crystalline defects, atomistic simulations.

Research Assistant Professors

Antal, S.—Ph.D. (Rensselaer Polytechnic Institute); computational fluid dynamics, numerical methods in multiphase flows, heat transfer.

Kim, C.H.—Ph.D. (Texas A&M University); Monte Carlo radiation transport, dosimeter simulation, organ dose calculation, medical physics dosimetry, shield design, radiation field characterization.

Wang, X.—Ph.D. (Texas A&M University); microscale heat transfer and fluid flow in porous media, microheat pipes and its applications, microelectronic cooling and electronic packaging.

Senior Lecturer

Swersey, B.L.—B.S. (Cornell University); creativity in design, design methodology.

Lecturer

McDougall, R.—B.S. (Rensselaer Polytechnic Institute); mechatronics.

Adjunct Faculty

Anderson, T.—Ph.D. (New York University); plasma physics, fluid dynamics, reactor physics and waste management, environmental engineering.

Borton, D.N.—Ph.D. (Rensselaer Polytechnic Institute); solar energy.

Caracappa, P.—M.S. (Rensselaer Polytechnic Institute); radiation safety, health physics.

DeLorey, T.E.—Ph.D. (Massachusetts Institute of Technology); reactor physics, computational physics, software engineering.

Feitelberg, A.S.—Ph.D. (Massachusetts Institute of Technology); combustion.

Francis, N.—Ph.D. (University of Rochester); reactor physics.

Haley, T.—Ph.D. (Rensselaer Polytechnic Institute); nuclear fuel management, mathematical modeling, reactor design.

Ting, J.K.—M.S. (Massachusetts Institute of Technology); energy systems.

Trumbull, T.H.—M.Eng. (Rensselaer Polytechnic Institute); research reactor experimental operations.

Witter, J.K.—Ph.D. (Massachusetts Institute of Technology); reactor physics, plant operations, thermal hydraulics, reactor for space applications.

Emeritus Faculty

Bergles, A.E.—P.E., NAE, Ph.D. (Massachusetts Institute of Technology); heat transfer, two-phase flow.

Block, R.C.—Ph.D. (Duke University); nuclear structure and data, radiation effects in electronics, accelerator technology neutron reactions, real-time radiography, industrial applications of radiation, nondestructive testing.

Ettles, C.M.—Ph.D. (Imperial College), D.Sc. (University of London); mechanical design, machine dynamics, tribology.

Harris, D.R.—Ph.D. (Rensselaer Polytechnic Institute); reactor physics, fusion technology, shielding, reactor noise analysis.

Krempl, E.—Dr.Ing. (Technical University of Munich); continuum mechanics; mechanics of materials; creep, fatigue, inelastic analysis (Rosalind and John J. Redfern Jr. Professor of Engineering).

Lee, D.—Sc.D. (Massachusetts Institute of Technology); mechanics of materials, computer-aided manufacturing.
Nagamatsu, H.T.—Ph.D. (California Institute of Technology); hypersonics, transonics, plasma dynamics, aeroacoustics, heat transfer.

Sneck, H.J., Jr.—Ph.D., P.E. (Rensselaer Polytechnic Institute); viscous-fluid mechanics, bearing lubrication and design.

Somerscales, E.F.C.—Ph.D. (Cornell University); heat transfer.

Technical Support Staff
Brand, P.
Calabrese, S.J.
Gray, M.
Mielke, W.R., Jr.
Murray, S.F.
Paedelt, V.
Prince, L.
Stephens, J.
Trumbull, T.
Westhead, J.

Undergraduate Programs

Objectives of the Undergraduate Curriculum
While certain objectives of an undergraduate education in engineering are common to all programs, there are subtle but important differences that require some subset of objectives specific to ensuring that all graduates have specialized technical knowledge in their chosen field. In this regard, graduates of the Department of Mechanical, Aerospace, and Nuclear Engineering's baccalaureate program will:

■ Be able to apply skills in science and mathematics to the practice of engineering.
■ Through a broad education in the humanities and social sciences, be able to identify and treat problems of interest to society.
■ Have the ability to analyze real-world problems and to design products and systems for their solution.
■ Develop strong communication skills both oral and written.
■ Exhibit teamwork skills and leadership ability, working both within specialized and multidisciplinary settings, and form an awareness and appreciation of ethical and societal implications and the impact of engineering solutions in a global context.
■ Have a broad foundation in mechanical systems, thermal and fluids engineering, and electronics and controls; be able to apply their knowledge to the design of mechanical and thermal/fluids systems and devices; gain additional technical depth in one or more areas of concentration, such as aeronautics, applied energy systems, design optimization, dynamics, heat transfer and fluid mechanics, manufacturing, mechatronics, and mechanics of materials; and be familiar with basic laboratory techniques in mechanical and in thermal/fluids engineering or
■ Have a broad foundation in aerodynamics, aircraft structures, propulsion, and flight mechanics; be able to design and conduct experiments; and be familiar with basic numerical methods for engineering problems and the use of high-level computer software or
■ Develop and demonstrate the ability to apply relevant atomic and nuclear phenomena to nuclear and radiological systems and processes, conduct experimental investigations, and work on design projects
so as to be prepared to work professionally in one or more of the nuclear or radiological fields of specialization identified by the nuclear engineering program or

- Have a broad foundation in the application of engineering to physical systems and additional depth in one or more areas of concentration such as multiphase science, radiation technology, microelectronics, and applied mathematics; conduct experimental and analytical investigations and design projects; and develop the ability to work professionally in one or more of the areas of specialization identified by the engineering physics program.

- Be motivated for continued intellectual growth and improvement in engineering skill beyond graduation.

Students may achieve these objectives through completion of the B.S. degree in mechanical engineering, aerospace engineering, nuclear engineering, or engineering physics. A variety of options are available to those pursuing the B.S., depending upon the specific degree program. These options, which include concentrations, minors, and/or dual majors are delineated within the following individual descriptions of each baccalaureate curriculum.

**Baccalaureate Programs**

Freshmen or sophomores who have identified mechanical, aerospace, nuclear engineering, or engineering physics as their major may follow the baccalaureate program below in lieu of the general core engineering program presented earlier. The total number of credit hours required to complete any of these curricula is 128. Dual major programs which lead to a single baccalaureate degree embracing two fields are also available and are described in more detail below.

**Mechanical Engineering Curriculum**

**First Year**

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100 Intro. to Engineering Analysis ..........4</td>
<td>ENGR-1300 Engineering Processes 1,2 ..........1</td>
</tr>
<tr>
<td>ENGR-1200 Eng. Graphics and CAD 1 ...................1</td>
<td>ENGR-1600 Materials Science for Engineers ..........4</td>
</tr>
<tr>
<td>CHEM-1300 Chemistry Principles for Engineers ...4</td>
<td>MATH-1020 Calculus II ........................................4</td>
</tr>
<tr>
<td>MATH-1010 Calculus I ........................................4</td>
<td>PHYS-1100 Physics I ...........................................4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2530 Strength of Materials ........................4</td>
<td>ENGR-2050 Intro. to Engineering Design ..........4</td>
</tr>
<tr>
<td>MATH-2400 Intro. to Differential Equations ........4</td>
<td>ENGR-2090 Engineering Dynamics ........................4</td>
</tr>
<tr>
<td>PHYS-1200 Physics II ...........................................4</td>
<td>ENGR-2250 Thermal and Fluids Engineering I ..........4</td>
</tr>
<tr>
<td>CSCI-1190 Beginning C Programming for Engineers ..........4</td>
<td></td>
</tr>
</tbody>
</table>

1 These required courses may be taken in any order.

2 Alternative: ENGR-1310
Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of Uncertainty 3</td>
</tr>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation 4, Mechanical Engineering Core Module 6, Hum. or Soc. Sci. Elective 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2350</td>
<td>Embedded Control 4</td>
</tr>
<tr>
<td>ENGR-4050</td>
<td>Modeling and Control of Dynamic Systems 4</td>
</tr>
</tbody>
</table>

Concentrations

The mechanical engineering curriculum offers the following six concentration options.

Aeronautics

The focus is on the analysis, design, development, and operation of flight vehicles, which is fundamental for students interested in aeronautical engineering. This concentration provides a strong engineering and scientific foundation in fluid mechanics, thermodynamics, structural dynamics, vehicular mechanics, and control systems analysis. Student projects in recent years have involved spin prevention in fighter aircraft, trailing vortex dissipation, and helicopter maneuverability.

Applied Mechanics

This concentration provides the opportunity for fundamental study in fluid mechanics and solid mechanics. The objective is to develop broad analytical abilities and encourage critical inquiry. Programs in this area usually continue through the master’s level. Topics have included cellular heat convection, locally separated flow, and inelastic fatigue analysis and fracture. Biomechanics, especially the mechanics of musculoskeletal systems, is part of this concentration.

Design

The concern here is with design methodology in general and mechanical design techniques in particular.

---

3 Choice of Mechanical Design Module and Thermal and Fluids Module. Both modules are required for graduation; each module may be taken in either semester. The Mechanical Design Module consists of MANE-4030 and MANE-4040, taken concurrently. The Thermal and Fluids Module consists of MANE-4010 and MANE-4020, taken concurrently. Other third year courses may be taken in either semester.

4 This course will be fulfilled from a list published at the start of each semester. It must be completed before MANE-4260.

5 Can be taken either semester senior year.
and is intended for mechanical engineering students interested in the design of machinery and mechanical systems. A student interested in the design of specialized mechanical equipment can develop a suitable program from courses in this and other mechanical engineering concentrations.

**Energy Systems**

This concentration is intended for those interested in energy conversion and the development of mechanical power. Students concerned with the design of equipment in this field should consider this concentration together with the design concentration. Those interested in the fundamentals should consider this concentration together with the applied mechanics concentration.

**Manufacturing Concentration**

This area is intended for the mechanical engineering student who is interested in manufacturing and is planning a career designing manufacturing equipment, developing new manufacturing techniques, or operating manufacturing facilities.

**Space Technology**

This is an inherently multidisciplinary area that is offered for students interested in the analysis, design, development, and operations required for space exploration and utilization. Current areas of particular emphasis include the space environment, propulsion, orbital and structural dynamics, structures and control.

**Concentration Electives Criteria**

Students wishing to obtain any one of these concentrations must adhere to strict concentration electives criteria as follows. The first two courses within the four-course concentration are highly restricted. The first of these should be selected from the courses listed below. These courses define the concentration areas available within mechanical engineering and are thus termed “concentration-defining” electives.

### Applied Mechanics
- MANE-4670 Mechanical Behavior of Materials I
- MANE-4170 Machine Dynamics

### Aeronautics
- MANE-4070 Aerodynamics I
- MANE-4060 Aerospace Structural Analysis

### Design
- MANE-4280 Design Optimization
- MANE-4180 Mechanisms

### Energy Systems
- MANE-4710 Advanced Heat Transfer
- MANE-4720 Design and Analysis of Energy Systems
- MANE-4800 Boundary Layers and Heat Transfer

### Manufacturing
- MANE-4550 Analysis of Manufacturing Processes
- ENGR-4710 Advanced Manufacturing Laboratory I

### Mechatronics
- MANE-4490 Mechatronics

The second of the restricted concentration elective courses may be chosen from either:

- A list of courses associated with the originally defined concentration area. Such courses will be termed “concentration-completing” electives. Through them, a student clearly identifies a concentration within the mechanical engineering major.

- The original short list of concentration-defining electives. Through these, a student obtains greater breadth within mechanical engineering.

Any student wishing to satisfy these restricted concentration elective requirements in another way may first consult with the adviser and then propose a plan to the associate chair in undergraduate studies for approval. Students are reminded to consult the catalog and the Class Hour Schedule for the availability of a particular course in any given semester.
The second two courses of the four-course concentration are to be selected from any upper-level (4000 or above) course in science, engineering, or mathematics. One of these may be an independent study course, such as a design project or an undergraduate research project. The second course should not normally be a project. However, the associate chair for undergraduate studies may grant approval for an exception based on a particularly valuable research experience.

**Humanities or Social Sciences Electives**
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Dual Major Programs**
Dual majors lead to a single baccalaureate degree embracing two fields. Special programs which can be completed in eight semesters have been developed. Examples include dual majors in Mechanical Engineering and Aerospace Engineering, Mechanical Engineering and Biomedical Engineering, Mechanical Engineering and Nuclear Engineering, Mechanical Engineering and Product Design and Innovation (STS), and others. Further information is available in the departmental office.

**Aerospace Engineering Curriculum**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td>Intro. to Engineering Analysis ...........4</td>
<td>ENGR-1300</td>
<td>Engineering Processes 1,2 ..........1</td>
</tr>
<tr>
<td>ENGR-1100</td>
<td>Eng. Graphics and CAD 1 .................1</td>
<td>ENGR-2060</td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Chemistry Principles for Engineers ....4</td>
<td>MATH-1020</td>
<td>Fundamentals of Flight ..........4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Hum. or Soc. Sci. Elective .............4</td>
<td>PHYS-1100</td>
<td>Calculus II ..........4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ..................4</td>
<td></td>
<td>Physics I ..................4</td>
</tr>
<tr>
<td><strong>Second Year</strong></td>
<td>Strength of Materials ..................4</td>
<td>ENGR-2050</td>
<td>Intro. to Engineering Design ........4</td>
</tr>
<tr>
<td>Fall</td>
<td>ENGR-2530</td>
<td></td>
<td>Engineering Dynamics ..........4</td>
</tr>
<tr>
<td>ENGR-2530</td>
<td>Hum. or Soc. Sci. Elective .............4</td>
<td>ENGR-2090</td>
<td>Thermal and Fluids Engineering I ..........4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations ........4</td>
<td>ENGR-2250</td>
<td>Hum. or Soc. Sci. Elective ..........4</td>
</tr>
<tr>
<td>PHYS-1200</td>
<td>Physics II ..................4</td>
<td>CSCI-1190</td>
<td>Beginning C Programming for</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Engineers ..................1</td>
</tr>
<tr>
<td><strong>Third Year</strong></td>
<td>Modeling and Analysis of</td>
<td>ENGR-4050</td>
<td>Modeling and Control ..........4</td>
</tr>
<tr>
<td>Fall</td>
<td>Uncertainty ..................3</td>
<td>MANE-4030</td>
<td>Elements of Mechanical Design ..........4</td>
</tr>
<tr>
<td>ENGR-2600</td>
<td>Aerospace Structural Analysis ..........3</td>
<td>MANE-4900</td>
<td>Aeroelasticity and Structural</td>
</tr>
<tr>
<td>MANE-4060</td>
<td>Aerodynamics I ..................3</td>
<td>MANE-4920</td>
<td>Vibration ..................3</td>
</tr>
<tr>
<td>MANE-4070</td>
<td>Numerical Computing ..................4</td>
<td></td>
<td>Aerospace Structures and Controls</td>
</tr>
<tr>
<td>MATH-4800</td>
<td>Professional Development II 1,2 ..........2</td>
<td></td>
<td>Laboratory ..................2</td>
</tr>
</tbody>
</table>

1 These required courses may be taken in any order.
2 Alternative: ENGR-1310.
3 This course will be fulfilled from a list published at the start of each semester.
### Humanities or Social Sciences Electives

In this area, the electives are based on the Institute and School of Engineering requirements for these electives. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

### Dual Major Programs

A dual major in Aerospace Engineering and Mechanical Engineering is available to students who follow a prescribed program that can be completed in eight semesters. These students would choose ENGR-1600, ENGR-2350 and ENGR-4300 as free electives. General requirements and procedures for dual degrees are described within the Academic Information and Regulations section of this catalog.

---

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III ⁴ ..........1</td>
<td>Capstone Design Elective ⁶ ..........3</td>
<td></td>
</tr>
<tr>
<td>MANE-4080</td>
<td>Propulsion Systems ................................4</td>
<td>Free Elective ................................4</td>
<td></td>
</tr>
<tr>
<td>MANE-4800</td>
<td>Boundary Layers and Heat Transfer ..........3</td>
<td>Free Elective ................................4</td>
<td></td>
</tr>
<tr>
<td>Flight Mechanics Elective ⁵ ..........4</td>
<td>Free Elective ................................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MANE-4910</td>
<td>Fluid Dynamics Laboratory .................2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

⁴ Can be taken either semester senior year.

⁵ Choice of: MANE-4090, MANE-4100, or MANE-4200.

⁶ Choice of: MANE-4230, MANE-4850, or MANE-4860.
Nuclear Engineering Curriculum

First Year

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Eng, Graphics and CAD</td>
<td>1</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1600</td>
<td>Materials Science for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1300</td>
<td>Intro. to Eng. Processes or</td>
<td>1</td>
</tr>
<tr>
<td>ENGR-1310</td>
<td>Engineering Processes or</td>
<td></td>
</tr>
</tbody>
</table>

Second Year

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective I</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Hum or Soc. Sci. Elective</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2600</td>
<td>Modeling and Analysis of</td>
<td>3</td>
</tr>
<tr>
<td>ENGR-2830</td>
<td>Nucl. Phenomena for Eng. Appl.</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2050</td>
<td>Intro. to Eng. Design</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1190</td>
<td>Beginning C Programming for Engineers</td>
<td></td>
</tr>
</tbody>
</table>

Third Year

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2250</td>
<td>Thermal and Fluids Eng.</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation</td>
<td>4</td>
</tr>
<tr>
<td>MANE-2400</td>
<td>Fundamentals of Nuclear Eng.</td>
<td>4</td>
</tr>
<tr>
<td>Hum or Soc. Sci. Elective</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MANE-4400</td>
<td>Nucl. Power Systems Engineering</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4480</td>
<td>Physics of Nuclear Reactors</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4470</td>
<td>Radiological Engineering</td>
<td>4</td>
</tr>
<tr>
<td>Professional Development II</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Technical Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CSCI-1190</td>
<td>Beginning C Programming for Engineers</td>
<td></td>
</tr>
</tbody>
</table>

Fourth Year

Fall

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4050</td>
<td>Mod. and Control of Dynamic Sys.</td>
<td>4</td>
</tr>
<tr>
<td>MANE-4370</td>
<td>Nuclear Engineering and Eng. Phys.</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective II</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>MANE-4380</td>
<td>Senior Design Project I</td>
<td>1</td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III</td>
<td>1</td>
</tr>
</tbody>
</table>

Spring

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restricted (NE) Elective I</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Technical Elective II</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Restricted (NE) Elective II</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Senior Design Project II</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Free Elective III</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Concentrations

For more information on any of these concentrations, students should consult with their program adviser.

Reactor Physics

This area of concentration is intended for students who wish to develop expertise in the physics of nuclear power reactor cores. Topics such as reactor physics design, nuclear fuel management, and reactor startup physics tests are included.

1 May be taken in any order in the first two semesters.
2 Includes Professional Development I.
3 Any course in engineering or science at 4000 level or higher.
4 Can be taken either semester senior year.
**Reactor Engineering**
This area of concentration is intended for students who wish to develop a broad understanding of nuclear technology. Topics such as reactor thermal-hydraulics, reliability, safety and licensing, radioactive waste management, structural dynamics, and materials problems are included.

**Health Physics**
This area of concentration is intended for students who wish to develop expertise in the radiation safety aspects of nuclear power plant operations and the associated nuclear fuel cycle.

**Nuclear Thermal Hydraulics**
This area of concentration is intended for students who wish to develop an extended knowledge and the ability to apply principles of fluid mechanics and heat transfer in single-phase and multiphase gas-liquid systems to reactor engineering.

**Nuclear Plant Operations and Management**
This area of concentration is intended for students who wish to specialize in the operation and management of nuclear power plants. This concentration is directed toward students interested in careers with nuclear electric utility organizations.

**Fusion Reactor Engineering**
This area of concentration is intended for students who desire to develop expertise in the analysis, assessment, and design of fusion reactor power systems.

**Humanities or Social Sciences Electives**
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

**Dual Major Programs**
Dual major programs in Nuclear Engineering and Mechanical Engineering, and in Nuclear Engineering and Engineering Physics, are available to students who follow prescribed programs that can be completed in eight semesters. Further information is available in the departmental office.

**Minor Programs**
Students not majoring in nuclear engineering may receive a minor in this discipline by completing 15–16 credit hours of study selected in consultation with their program adviser.
# Engineering Physics Curriculum

## First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-1100</td>
<td>Intro. To Engineering Analysis ..........4</td>
<td>PHYS-1100</td>
<td>Physics I ...........................................4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .........................................4</td>
<td>MATH-1020</td>
<td>Calculus II ...........................................4</td>
</tr>
<tr>
<td>CHEM-1300</td>
<td>Chemistry Principles for Engineers ...4</td>
<td>Science Elective 1  .................................4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ...........4</td>
<td>Hum. or Soc. Sci. Elective ...........4</td>
<td>ENGR-1300</td>
<td>Engineering Processes or</td>
</tr>
<tr>
<td>ENGR-1200</td>
<td>Eng. Graphics and CAD 1 1 1</td>
<td>ENGR-1310</td>
<td>Intro. to Eng. Electronics 1 1 1</td>
</tr>
</tbody>
</table>

1 May be taken in any order in the first two semesters.

## Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200</td>
<td>Physics II ...........................................4</td>
<td>ENGR-2600</td>
<td>Modeling and Analysis of</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations ...........4</td>
<td>ENGR-2830</td>
<td>Nucl. Phenomena for Eng. Appl. ....4</td>
</tr>
<tr>
<td>Free Elective I ...........................................4</td>
<td>ENGR-2050</td>
<td>Intro. to Eng. Design ................................4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ...........4</td>
<td>Hum. or Soc. Sci. Elective ...........4</td>
<td>CSCI-1190</td>
<td>Beginning C Programming for</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Engineers ...........................................4</td>
</tr>
</tbody>
</table>

## Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4300</td>
<td>Electronic Instrumentation .................4</td>
<td>MANE-4470</td>
<td>Radiological Engineering .................4</td>
</tr>
<tr>
<td>MANE-4410</td>
<td>Appl. Atomic Nucl. Physics ................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted (EP) Elective I .............4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-4050</td>
<td>Mod. and Control of Dynamic Sys....4</td>
<td>MANE-4390</td>
<td>Restricted (EP) Elective II .............3</td>
</tr>
<tr>
<td>MANE-4370</td>
<td>Engineering Physics Lab ................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Free Elective II .........................4</td>
<td>Restricted (EP) Elective III .............3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MANE-4380</td>
<td>Senior Design Project I ................1</td>
<td>Technical Elective II 3 3 3</td>
<td></td>
</tr>
<tr>
<td>ENGR-4010</td>
<td>Professional Development III ........1</td>
<td>Senior Design Project II ..............2</td>
<td></td>
</tr>
</tbody>
</table>

1 May be taken in any order in the first two semesters.

2 Science Elective: ENGR-1600 or CSCI-1100 (C Programming not necessary after Computer Science I).

3 Includes Professional Development I.

4 Any course in engineering or science at 4000 level or higher.
Concentrations

Radiation Applications
This area of concentration is intended for students who wish to develop expertise in various industrial and other applications of radiation, including radiation damage or enhancement of materials, nondestructive testing, etc.

Radiation Effects on Electronics
This area of concentration is intended for students interested in using radiation techniques to create advanced solid-state electronic circuitry and/or those interested in understanding how optical/electronic devices respond to radiation.

Multiphase Science and Technology
This area of concentration is concerned with applications of fluid mechanics and heat transfer technology to the interactions between mixtures of gases, liquids, and solids.

Fusion Applications
This area of concentration deals with the development and engineering applications of plasmas and the analysis of advanced magnetic confinement and laser-driven fusion power systems.

Humanities or Social Sciences Electives
In this area, the electives are based on the Institute and School of Engineering requirements. Students are urged to elect humanities and social science sequences through which they will obtain adequate breadth and depth in subject areas. Students desiring minors in Humanities and Social Sciences must consult the school or department in which the courses are offered to obtain further information and specific requirements.

Dual Major Programs
A dual major program in Engineering Physics and Nuclear Engineering is available to students who follow a prescribed program that can be completed in eight semesters. Further information is available in the departmental office.

Minor Programs
Students not majoring in engineering physics may receive a minor in this discipline by completing 15–16 credit hours of courses selected in consultation with the program adviser.

Special Undergraduate Opportunities
Program for Graduates of U.S. Navy Nuclear Power Training School
Rensselaer’s School of Engineering and its Department of Mechanical, Aerospace, and Nuclear Engineering, in cooperation with the Office of Professional and Distance Education and the U.S. Navy, have developed undergraduate degree programs in nuclear engineering and engineering physics for graduates of the U.S. Navy Nuclear Power Training School. Currently, Rensselaer offers programs to personnel stationed at the Kesselring Site in West Milton, New York. These academic programs and resulting degrees are the same as those offered to on-campus students studying this discipline.

Designed to meet the needs of Navy personnel, this program delivers courses and degree programs at a time and place that is convenient to them. Student services are flexible and designed to accommodate the needs of working professionals. Services such as undergraduate admissions and registration are handled entirely by mail, phone, fax, or e-mail. Programs and classes are delivered to Rensselaer’s Malta
Commons campus, just 20 minutes from the Kesselring Site. The course schedule developed for the program is coordinated with the shift work schedule of the Navy personnel.

The total number of credit hours required for the B.S. degree in either engineering science or nuclear engineering is 128. The curriculum is comprised of 104 engineering and science credits and four professional development credits. Navy students receive up to 31 credit hours of transfer credits for their Navy Nuclear Power Training School course work, leaving 97 credit hours to be completed at Rensselaer. Courses from other accredited universities may also be considered for transfer. The following is a list of credit transfer courses for graduates of the U.S. Navy Nuclear Power Training School.

Toward a degree in engineering physics:

- ENGR-1300 Engineering Processes .................................................................1 transfer credit
- CHEM-1300 Chemistry Principles for Engineers ........................................4 transfer credits
- USNA-1010 Military and Its Place in Society ................................................1 transfer credit
- USNA-2040 Naval Ship Systems .................................................................3 transfer credits
- ENGR-2050 Intro. to Eng. Design with Prof. Development I ......................4 transfer credits
- ENGR-2940 Engineering Project ...............................................................3 transfer credits
- ENGR-2960 Topics in Engineering ..............................................................3 transfer credits
- ENGR-4300 Electronic Instrumentation ......................................................4 transfer credits
- MANE-4440 Critical Reactor Laboratory .....................................................3 transfer credits
- ENGR-4010 Professional Development III .................................................1 transfer credit

Toward a degree in nuclear engineering, in addition to the courses listed above:

- MANE-2400 Fundamentals of Nuclear Engineering .....................................4 transfer credits

The program has been divided into three trimesters (fall, spring, and summer) each calendar year. Students normally take three courses or 12 credit hours per trimester. Each trimester consists of approximately 15 weeks and averages a two-week break between any two consecutive trimesters. The total of 97 credits can usually be completed in two years plus seven to eight months.

Students with prior credits from other academic institutions may be eligible to transfer them to the present program. Rensselaer’s designated academic units are responsible for reviewing and approving such transfers. In addition, students may take a validation exam in selected subjects in place of some regular courses. Academic advisers provide advice and assistance in this regard.

Students must be in residence (i.e., enrolled as full-time students with a minimum of 12 credits per semester) for at least four semesters of their curriculum.

The academic director of this program is Michael Z. Podowski, and the program is administered through the Office of Professional and Distance Education.

Graduate Programs

The department offers graduate programs in mechanical engineering, aeronautical engineering, mechanics, nuclear engineering, and engineering physics. To accommodate a student’s career plans and interests, the graduate programs are structured to allow great flexibility in choosing appropriate courses, while ensuring sufficient depth and breadth. The professor assigned to or chosen by a student as the adviser has the knowledge to make suggestions of specific courses to further the student’s educational goals.

Among the available degrees are the M.Eng., which is perceived to be more practically oriented and consists of course work; the M.S., which is considered more scholarly or fundamental and must include a thesis; and Ph.D. Listed below are many of the requirements for these degrees. For all degrees, full-time stu-
Students must register each semester for the zero credit course MANE-6900, Graduate Seminar. Complete requirement information is available through the Office of Graduate Education.

**Master’s Programs**

**Master of Science**

Students work on a research project in conjunction with a professor who serves as the academic adviser. The topic is chosen based on mutual interests and needs. Course work typically focuses on subjects related to the research project. In addition to the Institute requirements and those listed above, the M.S. requires a total of 30 credits, six of which come from the thesis. Of the 24 credits of course work, a minimum of 12 must be at the 6000 level with a minimum of nine of these 6000-level courses from MANE (or courses that are cross-listed with MANE courses), and a minimum of 15 credits overall must be from MANE (or courses that are cross-listed with MANE courses). No more than six credits can be from outside of Engineering or Science.

**Master of Engineering**

M.Eng. students will primarily take courses to deepen and broaden their knowledge, usually in a focused area of study. If a project is included in the degree program, the student will have to involve a professor as an adviser. In addition to the Institute requirements and those listed above, the M.Eng. requires a total of 30 credits. If a project is taken, a minimum of 12 credits of coursework must be taken at the 6000 level with a minimum of nine of these taken within MANE (or courses cross-listed with MANE courses). If no project is undertaken, a minimum of 18 credits must be at the 6000 level, with a minimum of 12 of these taken within MANE (or courses that are cross-listed with MANE courses).

Students must also take part in a culminating experience consisting of:

- an approved sequence of three integrated or related courses with at least two courses in MANE, only one of which may be at the 4000 level. One of these courses must involve a project or design experience which integrates or synthesizes knowledge from other courses taken in the master’s program, or
- a six-credit project, or
- an internship/practicum involving a minimum of one summer and one semester full-time work in an approved setting.

**Doctoral Programs**

For the doctoral degree, 90 credits in addition to the bachelor’s or 60 credits in addition to the master’s degree are required. Usually, this means that 16 to 20 courses beyond the bachelor’s are needed, as specified by the adviser and the doctoral committee, in addition to residence and thesis requirements. Under the guidance of a thesis adviser, the student conducts advanced study and research. If a student chooses to do a thesis with a thesis adviser from another department, a Mechanical, Aerospace, and Nuclear Engineering Department faculty member must be appointed co-chair and the doctoral committee must contain at least two department faculty members. After approximately one year of full-time study, the student should have a research adviser and be advanced to doctoral student status. To attain this milestone a qualifying examination is required. When thesis research has begun and after approximately two years of full-time study, the candidacy examination is taken. At the completion of the research project and after the dissertation has been written, the student must defend the thesis in an open presentation to his or her committee. The degree awarded is the Doctor of Philosophy.
This degree is awarded under the auspices of the Office of Graduate Education when the thesis is directed toward making an original contribution to fundamental knowledge in a particular field or in an interdisciplinary field. A dissertation that is scholarly, creative, original, and publishable may deal also with the relation of a discipline to educational problems and objectives within the field.

Course Descriptions
Courses directly related to all Mechanical, Aerospace, Nuclear Engineering and Engineering Physics curricula are described in the Course Description section of this catalog under the department code MANE.

Engineering at Hartford
Chair: James C. McKim, Jr. (Interim)
Associate Chair: Ernesto Gutierrez-Miravete (Interim)
Department Home Page: http://www.rh.edu/engr/

Rensselaer at Hartford offers an engineering curriculum to accommodate the evolving needs of the engineer. The curriculum helps students establish and build on a solid theoretical base while allowing them to practice their skills. This blend of academic excellence and industrial experience creates a unique learning environment for engineering students at Rensselaer at Hartford. Degree programs are offered in Mechanical Engineering, Electrical Engineering, Computer and Systems Engineering, and Engineering Science together with certificate programs in Quality and Reliability Engineering, Systems Modeling and Analysis, and High Temperature Materials.

Engineering Degrees
Degrees are awarded in the following fields of engineering:
- M.Eng. in Computer and Systems Engineering
- M.S. in Electrical Engineering
- M.S. in Engineering Science
- M.S. in Mechanical Engineering

Candidates for the master’s degree must:
- Prepare a plan of study with their adviser and have it reviewed and approved by the chair of engineering no later than their fourth course
- Complete a plan of study with at least 30 credit hours beyond the bachelor’s degree with satisfactory grades. At least 18 of the total major credit hours presented toward the degree must have the suffix numbers 6000–6990 or 7000–7990.
- Complete all requirements within five years of admission.

Culminating Experience (Engineering Seminar)
The culminating experience is a requirement for the master’s degree in Connecticut. It may be fulfilled by any of the following:
- Submitting an engineering seminar paper (0 credit hours) in addition to the required 30 credit hours.
 Completing a six-credit-hour master’s thesis along with 24 credit hours of appropriate course work.
 Completing a three-credit-hour master’s project along with 27 credit hours of appropriate course work.

**General Engineering Requirements**

Students entering the engineering programs are expected to hold a Bachelor of Science degree. Students not holding a degree in one of the traditional engineering disciplines must have at least:

- Mathematics, through Ordinary Differential Equations (three terms or 12 credits)
- Physics (two terms)
- Chemistry and/or Engineering Materials (One term)
- Mechanics (One term)
- Electronics/Circuits (One term)

Students lacking one or more of these courses are expected to take corrective action before entering any of the engineering programs.

The Bachelor of Engineering Technology (BET) degree is not generally considered appropriate preparation for admission to master’s degrees and courses in engineering. Applicants with this degree may be required to do significant background repair and/or submit scores from the Graduate Record Examination Engineering test, along with the standard admissions credentials. Application forms for this test may be obtained from the Office of Admissions.

All students entering the engineering programs at Rensselaer at Hartford are expected to be familiar with one of the major higher level programming languages (Fortran, C, Pascal, etc.).

A limited number of elective courses outside a specific engineering discipline may be taken and credited toward an engineering degree. The student’s faculty adviser must approve these elective courses.

**Electrical Engineering**

The Electrical Engineering curriculum is designed for students who wish to focus their study in Digital Communications, Control Systems, and Digital Signal Processing.

A Bachelor of Science degree in Electrical Engineering is the desired background for admission to the program. Other students entering the program should have fulfilled the General Engineering Requirements noted above and the Electrical Engineering Background Requirements listed below.

**Electrical Engineering Background Requirements**

- Advanced Mathematics (i.e., Complex Variables, Laplace Transforms, Fourier Analysis, Probability) (One term)
- Digital Logic (One term)
- Electronics/Circuits (active or passive) (One additional term)
- Linear Systems or Feedback Systems (One term)
- Technical Design Elective (e.g., Communications Systems, Semiconductor Devices, Introduction to Microprocessors, Circuit Synthesis) (One term)

Students lacking any of the above courses must consult with their adviser to devise a plan for corrective action.
Electrical Engineering Program Requirements
The following must be included in a plan of study for the degree of Master of Science in Electrical Engineering:

- At least 18 credit hours in 6000-level courses (or equivalent with approval of adviser)
- At least 21 credit hours in ECSE courses or related technical work
- A three-course specialization to provide depth in an approved technical area
- Engineering Seminar

Specializations
From the courses currently available at Hartford, a three-course specialization can be constructed in any of the following areas:

- Digital Communications
- Control Systems
- Digital Signal Processing

The student may propose other areas, but they are subject to adviser’s approval.

Computer and Systems Engineering
The Master of Engineering in Computer and Systems Engineering provides the student with the appropriate hardware and software tools needed in such critical areas as digital communications and signal processing, robotics and automation systems, computer communication networks, and software engineering.

Admission Requirements
Students should have received a B.S. degree in Electrical Engineering, Computer Engineering, or Computer Science. Students with a B.S. degree in another engineering discipline, Mathematics or Physics, are subject to the condition that the following essential prerequisites for their chosen area of specialization have been completed:

<table>
<thead>
<tr>
<th>Digital Communications and Signal Processing</th>
<th>Robotics and Automation Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010 Electrical Circuits</td>
<td>ECSE-2010 Electrical Circuits</td>
</tr>
<tr>
<td>ECSE-2410 Signals and Systems</td>
<td>ECSE-2410 Signals and Systems</td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>ECSE-2610 Computer Components and Operations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Computer Communications Networks</th>
<th>Software Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECSE-2010 Electrical Circuits</td>
<td>CSCI-1100 Computer Science I</td>
</tr>
<tr>
<td>ECSE-2410 Signals and Systems</td>
<td>CSCI-2300 Data Structures and Algorithms</td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>ECSE-2610 Computer Components and Operations</td>
</tr>
</tbody>
</table>
Computer and Systems Engineering Program Requirements
The following must be included in a plan of study for the degree of Master of Engineering in Computer and Systems Engineering:

■ At least 18 credit hours in 6000-level courses (or equivalent with approval of adviser)
■ At least 21 credit hours in ECSE courses or related technical work
■ A three-course specialization to provide depth in an approved technical area
■ Engineering Seminar

Specializations
From the courses currently available at Hartford, a three-course specialization can be constructed in any of the following areas.

■ Digital Communications and Signal Processing
■ Computer Communication Networks
■ Robotics and Automation Systems
■ Software Engineering

The student may propose other areas, but they are subject to adviser’s approval.

Preparatory courses do not apply toward the minimum 30 credit hours required for the Master of Engineering degree.

Engineering Science
The Engineering Science curriculum serves students whose educational needs do not correspond to the standard professional engineering curricula. It allows students to tailor courses of study to their particular requirements. Each student’s course of study is developed in consultation with the Chair to allow a strongly directed interdisciplinary approach.

The degree awarded in this area is not, nor is it intended to be, accredited for practice. Students entering the Engineering Science program are expected to have fulfilled the General Engineering Requirements noted above.

Mechanical Engineering
The Master of Science in Mechanical Engineering allows the student to increase his or her competence in a number of mechanical engineering subjects, or to specialize in depth in the areas of fluid mechanics, heat transfer, mechanical design, solid mechanics, or thermodynamics.

A Bachelor of Science degree in Mechanical Engineering is the desired background for admission to the program. Other students entering the program should have fulfilled the General Engineering Requirements noted above, and the Mechanical Engineering Background Requirements listed below.

Mechanical Engineering Background Requirements

■ Chemistry (One additional term)
■ Statics (One term)
■ Dynamics (One term)
■ Strength of Materials (One term)
Fluid Mechanics (One term)
Heat Transfer (One term)
Mechanisms (One term)
Machine Design (One term)
Thermodynamics (Two terms)

Students lacking any of the above courses must consult with their adviser to devise plans for corrective action.

**Mechanical Engineering Program Requirements**

A plan of study must include the following items.

- MEAE-4960 Numerical Analysis for Engineers
- MEAE-7010 Math of Engineering and Sciences

(These courses may be waived if the student is competent in the subject.)

- At least 18 credit hours in mechanical engineering courses at an advanced level (or equivalent with approval of adviser). All courses with the suffix numbers 6000–6990 and 7000–7900 apply.
- At least 21 credit hours in MEAE courses
- A minimum of 30 credit hours, including Engineering Seminar. A limited number of elective courses outside the area of mechanical engineering are permitted. However, the student’s adviser must approve these courses.

**Graduate Certificate in Quality and Reliability Engineering**

The Department of Engineering at Rensselaer at Hartford offers a Graduate Certificate in Quality and Reliability Engineering integrating technical skills with business knowledge. The production of reliable products requires processes operating under control. The purpose of quality engineering is to measure and improve process control to increase the reliability of products and services. The Graduate Certificate in Quality and Reliability Engineering is designed to develop skills in the application of quality engineering principles to enhance the performance of industrial and business systems. The program consists of three, 3-credit-hour courses which are available via distance delivery. Credit from all of the following required courses can later be applied towards a master’s degree.

- DSES-6110 Introduction to Applied Statistics
- DSES-6170 Management of Quality Processes and Reliability
- DSES-6230 Quality Control and Reliability

**Graduate Certificate in Systems Modeling and Analysis**

Simulation and other types of modeling tools create manageable representations of complex systems. These models enable managers and technical analysts to study the feasibility and cost-effectiveness of alternative management policies and system designs. Modern simulation software provides easy access to graphical and computational analyses, which enable extensive experimentation with real and proposed systems before resources are committed. These analyses provide the decision support tools needed to assure the reliability, functionality, and efficiency of all types of industrial systems.

This Graduate Certificate is designed to provide skills in the development and interpretation of simulation models of real-world systems. Discrete event models of industrial engineering and management science systems are emphasized. The Systems Modeling and Analysis Graduate Certificate Program requires three 3-credit-hour courses which are available via distance delivery. Credit from all of the following required courses can then be applied towards a master’s degree.
Graduate Certificate in High Temperature Materials

Materials used in the “hot zones” of propulsion and power generation systems must satisfy stringent demands for integrity and performance. Materials exposed to these extreme environments exhibit continuously evolving microstructures, and this must be accounted for during the component design stage of production.

Rensselaer offers a Certificate of Advanced Graduate Studies in High Temperature Materials designed to provide an understanding of the properties of high temperature alloys as well as skills in improving those properties by manipulating the material microstructure through processing.

The Certificate of Advanced Graduate Studies in High Temperature Materials Technology in Propulsion and Power Generation is awarded on successful completion of three graduate level courses. Academic credit from these courses can then be applied towards a Master of Science degree.

Professional Engineering

Professional Engineering seminar topics and preparatory programs for the Professional Engineering Exams are provided in our Engineering course schedules and Web site. The exam review courses for Part I (EIT) and II (PE) and Land Surveyor are held evenings for 10 to 12 weeks prior to the April and October state exams. Rensselaer at Hartford works closely with the State of Connecticut to provide testing schedule information as well as application requirements.

- Fundamentals of Engineering (EIT) Review Course
- Professional Engineering Review Courses (Mechanical, Electrical, and Civil)
- Land Surveyor Review Course
Interdisciplinary Programs and Research

Rensselaer has long understood that neither student career interests nor modern industry needs are easily pigeonholed into a single discipline. In fact, the discovery of new and more advanced technologies more often than not results from combining the knowledge of a variety of disciplines. Rensselaer is, therefore, resolved to become a leader in providing numerous opportunities for interdisciplinary study.

In keeping with this commitment, the School of Engineering has developed a variety of special programs that bridge one or more departments or even Institute schools. These include both degree and research programs that allow students to develop a breadth and depth of knowledge in more than one discipline. By their nature, these programs are highly flexible and often involve working in teams with faculty and students representing multiple disciplines.

In addition to opportunities in the School of Engineering described below, other interdisciplinary programs available at Rensselaer are listed in the Interdisciplinary Studies Index of this catalog and are described fully in the section pertaining to the associated Institute school or division.

Engineering Science

Chair: Kevin C. Craig

Rensselaer’s engineering science curriculum serves students whose educational desires do not correspond to the standard professional engineering curricula. While no B.S. degree is offered in engineering science, M.S. and Ph.D. degrees are awarded to students whose programs of study are truly multidisciplinary. However, since each student develops an individual program in consultation with a faculty adviser, the program provides the opportunity to tailor programs of study to specific needs.

Studies may be based on the sciences. For example, programs may concentrate on the application of engineering and scientific techniques to areas between technology and the humanities and social sciences. Students may also develop a program providing a liberal education based on engineering and involving a critical appreciation of the increasingly technical culture. Such courses of study may form the basis for premedical, prelaw, or prebusiness programs.

Faculty

Product Design and Innovation

This dual major program, which the Schools of Engineering and Humanities and Social Sciences offer jointly, satisfies the requirements for the Bachelor of Science programs in both Mechanical Engineering and Science, Technology, and Society (STS). Product Design and Innovation (PDI) prepares students to become innovative designers who will develop and design the advanced products and technologies needed in the future. Built around a design studio every semester, PDI combines the technical sophistication of Rensselaer’s engineering curriculum with the insight and vision of the humanities and social science disciplines in the STS curriculum.

The design studio that students take every semester is the PDI core, which gives them a hands-on opportunity to bring together the two major curricula. The engineering curriculum provides a fundamental education in engineering science through basic courses in engineering mechanics, engineering electronics, energy, materials, and manufacturing. The STS curriculum provides a fundamental education in the eco-
onomic, ethical, cultural, and political dimensions of product development and innovation, including numerous case studies of successes and failures that help students learn what it takes to be effective leaders of design teams. Through the design studios, students explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.

The design experiences range from larger systemic problems to smaller focused problems, so that students have broad exposure to different applications of design practice. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from beginning to implementation. The studios also develop students’ skills in using computers and other advanced tools and techniques, as well as in drawing, visualizing, communicating, and working together.

PDI graduates are thus uniquely prepared to put their creativity to work as leaders of design and innovation, whether in a multinational business at the cutting-edge of the global market or in a smaller business that creates an unusual solution to a local problem. They are able to function effectively in the new situations and unfamiliar environments of a multicultural global society, to collaborate with diverse constituencies to analyze and formulate problems of varying complexities, and to work individually and in teams to develop truly innovative and powerful solutions to challenges affecting this country’s continued prosperity and social well-being. Programs corresponding to PDI are described in the School of Architecture and the Humanities and Social Sciences STS Department sections of this catalog.

Product Design and Innovation Curriculum

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2200 Design Studio I</td>
<td>4</td>
</tr>
<tr>
<td>STSH-1110 Introduction to STS (First-Year Studies)</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1011 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1500 Chemistry of Materials I</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1200 Engineering Graphics and CAD</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2020 PDI Studio II</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1100 Introduction to Engineering Analysis</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1600 Chemistry of Materials II</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-1300 Engineering Processes</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHSS-2500 Design Studio III</td>
<td>4</td>
</tr>
<tr>
<td>STSS-2960 Design Culture and Society</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400 Introduction to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1190 Programming</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR-2050 Intro to Engineering Design</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2530 Strength of Materials</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2090 Engineering Dynamics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200 Physics II for Engineers</td>
<td>4</td>
</tr>
</tbody>
</table>

1 These courses may be taken in any order.
2 PDI II, V, VI, and GMP satisfy the mechanical engineering requirement for the concentration electives in Product Design and Innovation.
3 For PDI students, IHSS-2500 can be used as a substitute for the second-year requirement in the STS area option.
The Center for Composite Materials and Structures (CCMS) has been established to coordinate and promote composites-related activities in four academic areas—civil, materials, and mechanical engineering and chemistry. Composites research activities at Rensselaer cover many facets of the subject and include mechanics-related topics such as the micromechanical modeling of elastic, thermal, fatigue, and failure phenomena; residual stress analysis and process modeling; constitutive equations for polymeric composites and viscoelastic characterization; design methodologies and numerical implementation for ceramic matrix composites; and materials-related topics such as interfacial adhesion and models of fiber-matrix stress transfer; nanoscale fillers and fibers for reinforcement; mechanisms of damping in filled elastomers; fiber and matrix characterization; environmental interactions; high temperature creep; long-term properties prediction, matrix and organic precursor synthesis; and civil-aeronautical topics such as the use of composites for infrastructure construction and joint analysis. Materials of interest include all polymer, ceramic, and metal matrix composite systems.

For the past 20 years, Rensselaer has been a leader in the training of undergraduates with an exposure to composites. Undergraduates have designed, fabricated, and tested to specifications several all-composite gliders. As many as 70 juniors and seniors participate in the program in any given year. The third-generation glider, the RP-3, was successfully flight-tested recently.

---

**Center for Composite Materials and Structures**

**Director:** Sanford S. Sternstein

**CCMS Home Page:** [http://www.eng.rpi.edu/WWW/Research/res_centers/ccms.html](http://www.eng.rpi.edu/WWW/Research/res_centers/ccms.html)

The Center for Composite Materials and Structures (CCMS) has been established to coordinate and promote composites-related activities in four academic areas—civil, materials, and mechanical engineering and chemistry. Composites research activities at Rensselaer cover many facets of the subject and include mechanics-related topics such as the micromechanical modeling of elastic, thermal, fatigue, and failure phenomena; residual stress analysis and process modeling; constitutive equations for polymeric composites and viscoelastic characterization; design methodologies and numerical implementation for ceramic matrix composites; and materials-related topics such as interfacial adhesion and models of fiber-matrix stress transfer; nanoscale fillers and fibers for reinforcement; mechanisms of damping in filled elastomers; fiber and matrix characterization; environmental interactions; high temperature creep; long-term properties prediction, matrix and organic precursor synthesis; and civil-aeronautical topics such as the use of composites for infrastructure construction and joint analysis. Materials of interest include all polymer, ceramic, and metal matrix composite systems.

For the past 20 years, Rensselaer has been a leader in the training of undergraduates with an exposure to composites. Undergraduates have designed, fabricated, and tested to specifications several all-composite gliders. As many as 70 juniors and seniors participate in the program in any given year. The third-generation glider, the RP-3, was successfully flight-tested recently.

---

2 PDI II, V, VI, and GMP satisfy the mechanical engineering requirement for the concentration electives in Product Design and Innovation.

4 Candidate courses include STSS-4350; STSS-4960; STSS-4960; STSH-4230; STSS-4110; STSS-4250; STSS-4310; STSS-4560; and STSS-4650.

5 This course satisfies the requirement for Professional Development II.

6 The STS Senior Project can be combined with the PDI Capstone Design Studio to make an 8-credit capstone studio project. Coordination should be done with your PDI advisor.
Courses covering all areas of composites from materials and processing to properties, micromechanics, and design are offered yearly. Joint activities with SCOREC (Scientific Computation Research Center) include the numerical implementation of advanced computational schemes for the modeling of fabrication processes, mechanical properties evaluation, and structural design and analysis. Interdisciplinary students are strongly encouraged at Rensselaer and are essential for studies in the composites field.

**Affiliated Faculty**

**Civil Engineering:** J. Fish, M.S. Shephard

**Materials Engineering:** P. Ajayan, R.H. Doremus, D.J. Duquette, W.B. Hillig, L. Schadler, R. Siegel, S.S. Sternstein

**Mechanical Engineering:** G. Dvorak, P. Hajela, H.J. Hagerup, E. Krempl

**Chemistry:** J.V. Crivello, L.V. Interrante, J.A. Moore

---

**Center for Image Processing Research**

**Director:** William A. Pearlman

**Associate Director:** John W. Woods

**CIPR Home Page:** [http://www.cipr.rpi.edu](http://www.cipr.rpi.edu)

The Center for Image Processing Research (CIPR) conducts a range of research and academic programs in image and video processing. Faculty participants represent a number of academic disciplines and, together with their students, provide the nucleus for ongoing activities within CIPR. In addition to providing an intellectual focus for image-processing activities at Rensselaer, the objectives are to provide a positive impact on graduate and undergraduate programs, to support ongoing activities with a world-class infrastructure, and to enhance its reputation as one of the world’s premier image-processing research centers. Current CIPR research areas include image modeling, computer vision and image analysis, document analysis and processing, image and video enhancement and reconstruction, biomedical image processing, computer graphics, computational geometry, image and video compression and transmission, virtual video synthesis, visualization and display techniques, and multimedia systems. The CIPR has administrative authority over and shares infrastructure with the NSF Industry/University Center for Next Generation Video (CNGV) and the NSF Engineering Research Center for Subsurface Sensing and Imaging System (CenSSIS) at Rensselaer. These centers have some joint research programs with CIPR, but otherwise operate independently of CIPR.

**Affiliated Faculty**

Center for Infrastructure and Transportation Studies

Director: George F. List

Director of Research: William A. Wallace

Senior Research Associate: Donald N. Geoffroy

CITS Home Page: http://www.rpi.edu/dept/cits

The Center for Infrastructure and Transportation Studies (CITS) provides a focal point for campus research addressing the world’s infrastructure and transportation needs. CITS also assists in coordinating all related pedagogical initiatives. About 15 faculty across the Institute participate.

The Center’s research program focuses on five themes: intelligent transportation systems, information technology, deployment, and application, network analysis and control, asset management, and advanced materials. Each aspect of the life cycle for infrastructure and transportation systems is of interest—planning, analysis, design, maintenance, operation, preservation, restoration, and renewal. Common infrastructure focal points are roadways, bridges, and power distribution networks.

Projects currently under way include wireless ATIS systems, incident management systems, critical infrastructure interdependencies, investment planning for multimodal freight networks, capacity analyses for highway facilities, multilayer network modeling, and advanced concrete technologies. The pedagogical activities include course material development in the areas of intelligent transportation systems and asset management.

Affiliated Faculty

Center for Multiphase Research

Director: Michael Z. Podowski

CMR Home Page: http://www.ne.rpi.edu/cmr

In this country, Rensselaer’s interdisciplinary Center for Multiphase Research (CMR) is the premier research center of its kind. The CMR has assembled a large and dynamic group of scientists and engineers dedicated to exploring and exploiting new developments in every conceivable aspect of multiphase flow and heat transfer technology. The CMR coordinates the diverse activities of these researchers and facilitates the cross-disciplinary exchange of information as well as technology transfer to industry.

Multiphase flow occurs in any physical process or industrial system involving more than one phase (solids, liquids, and vapors). Multiphase flow and related heat transfer technology are the keys to increasing the productivity and efficiency of many American industries. Indeed, this technology underlies our understanding of crystal growth, foundry casting, high-power density electronic cooling, chemical processing, petroleum refining, and slurry and pneumatic transport. Multiphase technology also has basic applications to aircraft wing icing, deep-sea mining, aseptic food processing, pharmaceutical manufacturing, refrigeration and air conditioning, chemical and nuclear reactor safety, foam production, aerosols, particulate erosion, combustion, processing and propulsion in outer space, enhanced petroleum recovery and bioreactors. Moreover, there are many important defense applications for this technology.
Historically, multiphase flows have been analyzed empirically. As a result, these analyses necessarily included many uncertainties and inaccuracies. Thus, the design and operation of phase change equipment had to include large margins. Recent developments in supercomputing, symbolic manipulator algorithms, diagnostic instrumentation, and applied mathematics have driven revolutionary changes in scientists’ ability to understand and predict multiphase flow phenomena.

The research activities of the CMR involve faculty, staff, and graduate students of many backgrounds who work synergistically on relevant multiphase research. Some typical research projects are:

- Conducting crystal growth experiments in outer space.
- Developing state-of-the-art laser optical diagnostic system for measuring multidimensional phenomena.
- Developing CFD models of multiphase flows.
- Predicting critical heat flux (CHF) using first principle models.
- Understanding instability phenomena in various phase change systems.
- Investigating laser materials processing, thin film behavior, and ultrahigh boiling heat fluxes.
- Imaging interfacial structures in gas/liquid flows.
- Assessing the consequences of hypothetical nuclear reactor accidents.

The members of the center represent a broad spectrum of science and engineering disciplines and have access to a wide variety of equipment and computational power.

**Affiliated Faculty**


**Center for Next Generation Video**

**Director:** John W. Woods  
**CNGV Home Page:** [http://www.ecse.rpi.edu/CNGV](http://www.ecse.rpi.edu/CNGV)

The Center for Next Generation Video (CNGV) is an NSF Industry-University Cooperative Research Center dedicated to advancement of the state-of-the-art in compression, transmission, reception, processing, and networking of digital video and multimedia. The Center is operated in partnership with the New Jersey Institute of Technology, with Rensselaer as its headquarters.

**Center for Subsurface Sensing and Imaging Systems**

**Director:** Badrinath Roysam  
**CenSSIS Home Page:** [http://www.ecse.rpi.edu/cen시스](http://www.ecse.rpi.edu/cen시스)

The Center for Subsurface Sensing and Imaging Systems (CenSSIS) is a National Science Foundation Engineering Research Center (NSF-ERC) that conducts multidisciplinary research on common solutions to diverse problems for sensing and imaging objects that are hidden under a surface. This is part of a larger center involving Northeastern University, Boston University, University of Puerto Rico at Mayagüez, and several affiliate institutions including The Woods Hole Oceanographic Institute, Memorial Sloan-Kettering Cancer Center, Massachusetts General Hospital, Idaho National Engineering and Environmental Laboratory, and Lawrence Livermore National Laboratory. Examples of applications include deep confo-
cal laser-scanning microscopy of minute subcellular objects, electrical impedance tomography of the human body and underground waste sites, retinal imaging, surgical planning for radiation treatment, and inspection of hidden defects in roads and bridges. These diverse applications are addressed using advanced computer algorithms for tomographic image reconstruction, image analysis, and computer vision. Some projects involve design and fabrication of working prototypes using advanced electronics, processors, and embedded algorithms. Graduate and undergraduate students participate on various projects at the center. Opportunities also exist for qualified K-12 students to participate in selected projects.

**Affiliated Faculty**

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degrees Offered and Associated Departments</td>
<td>234</td>
</tr>
<tr>
<td>Overview of Undergraduate Programs</td>
<td>234</td>
</tr>
<tr>
<td>Overview of Graduate Programs</td>
<td>236</td>
</tr>
<tr>
<td>The Arts</td>
<td>237</td>
</tr>
<tr>
<td>Cognitive Science</td>
<td>243</td>
</tr>
<tr>
<td>Economics</td>
<td>251</td>
</tr>
<tr>
<td>Language, Literature, and Communication</td>
<td>256</td>
</tr>
<tr>
<td>Science and Technology Studies</td>
<td>267</td>
</tr>
<tr>
<td>Interdisciplinary Programs and Research</td>
<td>277</td>
</tr>
</tbody>
</table>
School of Humanities and Social Sciences

Dean: John P. Harrington

Associate Dean of Undergraduate Programs and Curriculum Initiatives: Lee O'Dell

Associate Dean of Graduate Programs and Research Initiatives: Kim Fortun

Director of Student Services: Elizabeth Large

Director of Program Development: Dean Button

Director of External Communication: Donald Moore

School of Humanities and Social Sciences Home Page: http://www.rpi.edu/dept/hss/

In an historic technological institution, the Rensselaer School of Humanities and Social Sciences (H&SS) offers exciting new institute research areas as well as broad university educational opportunities. The School’s five departments offer innovative and interdisciplinary programs of study at both the undergraduate and graduate levels. The undergraduate programs include: majors in humanities, social science, and arts disciplines; collaborations and dual majors for students of all schools; and a core curriculum that is a common element in the course of study for all Rensselaer students. The graduate programs in H&SS offer unique opportunities for study of the technological world, its impact on society, and its potential contributions to social, cultural, and artistic goals. All H&SS students have a broad choice of electives representing Rensselaer’s global vision and commitment to personal excellence though new studies in arts, communications, and culture studies as well as to the traditional areas of liberal arts and social sciences.

H&SS programs at Rensselaer give every student close contact with outstanding faculty members. Those faculty — scholars and practitioners themselves — create programs that are distinctive for research applications at both the undergraduate and graduate levels, field work and studio experiences, internships and professional co-op opportunities, outstanding electronic laboratories and computer facilities, and, above all, opportunities to cross boundaries and to develop new interdisciplinary projects. These programs integrate the intellectual depth and the practical experience needed for leadership careers in business, non-profit corporations, government and government-related organizations, higher education, and arts. Our students do not only participate in the technological world: they create it, and they shape it.

Undergraduate and graduate degree programs are offered in five-degree granting departments, including Arts; Cognitive Science; Economics; Language, Literature, and Communication; and Science and Technology Studies. In addition, students can major in interdisciplinary programs that integrate scientific and technical tools with the arts, social sciences, communication, and humanities. These include Electronic Media, Arts, and Communication (EMAC); Minds and Machines; Product Design and Innovation (PDI); and Ecological Economics, Values, and Policy (EEVP).
**Degrees Offered and Associated Departments**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Associated Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>Language, Literature, and Communication</td>
</tr>
<tr>
<td>Communication and Rhetoric</td>
<td>Language, Literature, and Communication</td>
</tr>
<tr>
<td>Ecological Economics</td>
<td>Economics</td>
</tr>
<tr>
<td>Ecological Economics, Values, and Policy</td>
<td>Interdisciplinary</td>
</tr>
<tr>
<td>Economics</td>
<td>Economics</td>
</tr>
<tr>
<td>Electronic Arts</td>
<td>Arts</td>
</tr>
<tr>
<td>Electronic Media, Arts, and Communication</td>
<td>Interdisciplinary</td>
</tr>
<tr>
<td>Minds and Machines</td>
<td>Interdisciplinary</td>
</tr>
<tr>
<td>Philosophy</td>
<td>Cognitive Science</td>
</tr>
<tr>
<td>Product Design and Innovation</td>
<td>Interdisciplinary</td>
</tr>
<tr>
<td>Psychology</td>
<td>Cognitive Science</td>
</tr>
<tr>
<td>Science, Technology, and Society</td>
<td>Science and Technology Studies</td>
</tr>
<tr>
<td>Science and Technology Studies</td>
<td>Science and Technology Studies</td>
</tr>
<tr>
<td>Technical Communication</td>
<td>Language, Literature, and Communication</td>
</tr>
</tbody>
</table>

**Overview of Undergraduate Programs**

Individual departments in the School of Humanities and Social Sciences offer a variety of Bachelor of Science degree programs. H&SS currently offers departmental degree programs in Communication, Economics, Electronic Arts, Philosophy, Psychology, and Science and Technology Studies.

In addition, a number of interdisciplinary programs are also available. These programs are offered jointly between two or more departments within the school or with other Institute schools. H&SS interdisciplinary degree programs include the following, all of which are explained in greater detail under the heading Interdisciplinary Programs and Research at the end of the H&SS section of this catalog.

- **Electronic Media, Arts, and Communication (EMAC)** – The departments of Arts and of Language, Literature, and Communication (LL&C) offer this B.S. degree, which combines theory and practice through electronic media arts studio and theory courses.

- **Ecological Economics, Values, and Policy (EEVP)** – The departments of Economics and of Science and Technology Studies (STS) offer this B.S. degree. It combines ecological economics, environmental policy studies, and social and cultural theory and practice.

- **Minds and Machines (M&M)** – This B.S. degree based in the department of Cognitive Science includes substantial hands-on and research-based work in artificial intelligence, psychology, cognitive science, logic, and philosophy.

- **Product Design and Innovation (PDI)** – This innovative design program offers a dual major with three possibilities, Mechanical Engineering and STS, Engineering Science and STS, or Building Sciences and STS. This program combines engineering or architectural disciplines, STS courses, and design studios.
In all curriculum areas, H&SS strives to provide flexibility whenever possible. As part of this effort, the department offers the Independent Study Program, which fills specialized educational needs in areas that regular departmental offerings do not adequately serve. Independent Study is an individualized reading or research program that a student proposes to a faculty member whose expertise covers that area. Students interested in Independent Study must adhere to a number of conditions including:

- Demonstration of an ability to work independently as well as completion of the prerequisites needed to undertake the project successfully.
- Evidence that no equivalent course is available at Rensselaer or at any of the consortium institutions in the Capital District or that the student is unable to schedule such a course due to unusual curricular demands.
- The faculty member has sufficient time to supervise the proposed course of study.
- Development of a written agreement spelling out the scope of the work to be done, the expected deliverables, and the evaluation criteria to be applied.
- Provision of a description of the amount of work expected and an understanding that the level at which it is to be completed must be similar to the demands of an equivalent course.
- The ability of faculty members to place additional constraints on the participation in the Independent Study.

**H&SS Core Program**

As part of their B.S. degree program, all Rensselaer undergraduates take a selection of H&SS courses referred to as the H&SS core. This core is the foundation of undergraduate education. In it, students develop the skills necessary for personal and professional success, and they also begin to explore the social and cultural areas of study and issues of debate that are important in the global society of the twenty-first century.

The core consists of 24 credit hours, or six courses distributed to afford students a breadth of perspective across the various disciplines as well as a more in-depth experience in at least one area. Engineering students automatically take two of the 24 credit hours as professional development in their engineering design sequence and take a two-credit H&SS professional development course in their junior year.

To ensure breadth in the core courses, students must select at least two courses (eight credit hours) from each of the lists below.

**Humanities**

<table>
<thead>
<tr>
<th>Code</th>
<th>Social Sciences</th>
</tr>
</thead>
<tbody>
<tr>
<td>LANG</td>
<td>Economics</td>
</tr>
<tr>
<td>LITR</td>
<td>Science and Technology Studies, Social Science</td>
</tr>
<tr>
<td>COMM</td>
<td>Psychology</td>
</tr>
<tr>
<td>WRIT</td>
<td>Interdisciplinary Studies</td>
</tr>
<tr>
<td>ARTS</td>
<td></td>
</tr>
<tr>
<td>PHIL</td>
<td></td>
</tr>
<tr>
<td>STSH</td>
<td></td>
</tr>
<tr>
<td>IHSS</td>
<td></td>
</tr>
</tbody>
</table>

**H&SS interdisciplinary courses may be substituted for courses in either category.**

To ensure depth in the H&SS core, students must also take at least two courses within a single area code (STSH and STSS can be counted as a single area), at least one of which is taken at an advanced level (above 1000). No course within the depth sequence may be taken as Pass/No Credit.
No more than three 1000-level H&SS courses may be applied toward the H&SS core requirement, no more than six credits may be taken as Pass/No credit, and at least one course (four credits) must be at the 4000 level.

Students entering Rensselaer in their first year may transfer up to two H&SS courses (up to eight credit hours) toward their H&SS core requirement (including Advanced Placement credit). Transfer students from an accredited collegiate program who have completed at least one college year but who come to Rensselaer with first-year status may qualify for additional core transfers at the discretion of the H&SS curriculum adviser.

Transfer students entering Rensselaer at the sophomore level or above are not limited in the number of courses they may transfer for H&SS core credit. All other must take at least 16 credit hours of their H&SS core at Rensselaer.

Enrolled Rensselaer students wishing to take an H&SS course for credit at another accredited institution must obtain prior approval for the course from the core curriculum adviser. Applicants must furnish a catalog description of the proposed course and a completed copy of Rensselaer’s Transfer Credit Approval form to the core curriculum adviser. A maximum of two courses (up to eight credit hours) of transfers is allowed (including AP courses).

**Special Undergraduate Opportunities**

**Accelerated Prelaw Program** – This opportunity is offered within the Department of STS in cooperation with Albany Law School and other law schools. For additional details, see the Science and Technology Studies section of this catalog.

**Overview of Graduate Programs**

The School of Humanities and Social Sciences offers both master’s and doctoral level programs. In addition, it provides a selection of special certificate program opportunities.

**Master’s Programs**

Within H&SS, three types of master’s degrees are available. Among these is a 30-credit-hour M.S. degree, which is offered within the departments of Language, Literature, and Communication, Economics, Cognitive Science, and Science and Technology Studies.

Another 30-credit-hour Professional Master’s program is intended for individuals already in the work force who are seeking a professional focus. Professional Master’s are available in Ecological Economics, Values, and Policy (EEVP). Finally, H&SS offers a 60-credit-hour Master of Fine Arts in Electronic Arts through the Arts Department.

**Doctoral Programs**

Programs leading to the Doctor of Philosophy degree (Ph.D.) are offered in Ecological Economics, Science and Technology Studies, and Communication and Rhetoric. Individual courses and opportunities for directed study are also available in other areas.

**Special Graduate Opportunities**

Certificate Programs – The Department of LL&C offers two specialization certificates, one in Graphics and the other in Human-Computer Interaction, as options in the master’s degree in technical communication.
The Arts
Chairman: Michael Century
Director of Graduate Studies: Kathy High
Director of iEAR Studios: Curtis Bahn
Department Home Page: http://www.arts.rpi.edu/

The Department of the Arts offers a B.S. in Electronic Arts and a graduate program leading to an M.F.A. in Electronic Arts. Also offered jointly with the Department of Language, Literature, and Communication is a B.S. in Electronic Media, Arts, and Communication.

Within this department, studio courses engage students in hands-on activities that stress creative and expressive development. They also encourage students to develop their perceptual sensitivity, as well as build the confidence to apply creative exploration and problem-solving skills to a wide range of aesthetic challenges. In addition to a full complement of traditional disciplines such as drawing, painting, sculpture, music, and acting, the department offers courses in electronic media including digital video, computer imaging and animation, interactivity, virtual reality, multimedia installation, and computer music.

Rensselaer’s Master of Fine Arts offers a unique emphasis on integrating a variety of electronic arts disciplines into a single curriculum. Building upon undergraduate backgrounds in music composition or the visual arts, this program provides professional-level training in a technologically sophisticated artistic environment. The 60-credit degree emphasizes developing creative skills in digital video, computer music, imaging, animation, interactive media, performance, and installation art.

Research Innovations and Initiatives
Arts department faculty members take varying approaches to the use of electronic media in artistic creation and performance. All are active artists whose works are represented internationally in museums, galleries, and performances.

Arts students are required to become familiar with creative tools in a variety of electronic media and are encouraged to work with combinations of media. The center of such creative work is the Integrated Electronic Arts at Rensselaer (iEAR) Studios, which include professional quality facilities in electronic and computer music, digital video production and post production, computer imaging and animation, interactive media, installation art, and performance art. In addition, qualified students in the M.F.A. program may use elective credits to explore Rensselaer’s extensive technological resources. Numerous opportunities to engage in creative or research projects with students or faculty from other departments or schools within the Institute are also available.

Faculty*
Professors
Canier, C.—M.F.A. (Boston University); painting, drawing.
Century, M.—Ph.D. (University of Sussex); musicology, music composition, improvisation and performance.
Goebel, J.—M.A. (Staatliche Hochschule für Music und Theater); music composition and performance.
Kagan, L.—M.A. (University at Albany, SUNY); studio arts.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Miller, B.—M.F.A. (New York University Graduate Film and Television Program); video art, media art.
Rolnick, N.—Ph.D. (University of California, Berkeley); music composition, electronic and computer
music, electronic arts.

Distinguished Research Professor of Music
Oliveros, P.—Honorary Dr. of Music (University of Maryland, Baltimore County); music composition,
electronic music, improvisation.

Associate Professors
Bahn, C.—Ph.D. (Princeton University); computer music and interactive performance.
High, K.—M.A.H. (SUNY-Buffalo, Center for Media Study): video, film, photography/production and
theory.
Staniszewski, M.—Ph.D. (Graduate School and University Center, City University of New York); art his-
tory and critical theory.

Assistant Professors
Bustamante, N.—M.F.A. (San Francisco Art Institute); new genres, performance art, video, installation.
Hahn, T.—Ph.D. (Wesleyan University); ethnomusicology, Japanese & contemporary music and dance,
choreography.
Ruiz, K.—M.A. (New York University); interactive and computer art.
Thornton, K.D.—M.F.A. (School of the Art Institute of Chicago); art and technology, installation/new
media/sculpture.
Vamos, I.—M.F.A. (University of California at San Diego); video, film production and theory.

Clinical Professors
Gibson, D.—M.M. (Yale School of Music); music history and theory, orchestra performance, cello.
Shur, P.—Ph.D. (St. Petersburg Institute of Theatre, Music and Film); theatre.

Undergraduate Programs
At Rensselaer, the Department of the Arts offers bachelor’s degree programs in Electronic Arts, Information
Technology-Arts, and Electronic Media, Arts, and Communication (EMAC). Information and require-
ments specific to each program are described below.

Baccalaureate Programs
As explained in the Humanities and Social Sciences introduction, all baccalaureate students take 24 cred-
it hours of core courses. The Institute also requires all students to complete a 24 credit hour math/science
requirement. Required courses in mathematics and sciences are: MATH-1500 Calculus I for Humanities
and Social Science, MATH-1620 Contemporary Ideas in Math, and CSCI-1100 Computer Science.
MATH-1010 Calculus I and MATH-1020 Calculus II may be substituted for MATH-1500 and MATH-
1620, respectively. To ensure depth in their science core, students must take at least two four-credit cours-
es within a single area other than mathematics. One-credit courses that are graded satisfactory/unsatis-
factory do not satisfy science requirements. For more information, see a departmental adviser.

Electronic Arts Curriculum
The B.S. degree in Electronic Arts allows students to pursue an arts degree that particularly emphasizes the
use of technology and an interdisciplinary approach to electronic arts, including computer music, interactiv-
ity, video, computer imaging, animation, web, multimedia installation, and performance art. The degree is
designed for students who aspire to be artists and are also strong in math, science, and technology.
The program prepares students for careers in which technology is used in producing works of art and music.
It also prepares students for graduate studies in the electronic arts. The program integrates an intensive curriculum of studio and theory courses in electronic and traditional arts and music with Rensselaer’s rigorous core requirements in math and science. Situated within the context of a technological university, Rensselaer’s arts program offers a unique creative environment in which to develop and realize electronic art.

Rensselaer’s location within a thriving community of technological innovation and proximity to art and cultural centers such as Williams College, Massachusetts Museum of Contemporary Art (MASS MoCA), Bard College, and Bennington College further strengthens its arts programs.

Applicants must submit a portfolio and written statement of interest. In this statement, an applicant should address his or her specific interests in the program, desire to work with electronic media, and a description of work submitted in the portfolio. The successful portfolio should include 10 to 20 examples of an applicant’s best work in any medium, such as drawings, paintings, photographs, slides, CD-ROMS, video and audio recordings, music scores, and digital images.

Once accepted into the program, an undergraduate electronic arts student can expect to follow a program of courses similar to the following.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS-1010 Media Studio: Video/Audio**</td>
<td>4</td>
<td>ARTS-1020 Media Studio/Imaging**</td>
<td>4</td>
</tr>
<tr>
<td>ARTS-1200 Basic Drawing</td>
<td>4</td>
<td>MATH-1620 Contemporary Ideas in Math</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td>H&amp;SS Elective</td>
<td>4</td>
</tr>
<tr>
<td>ARTS-2220 Fundamentals of 2-D Design</td>
<td>4</td>
<td>ARTS-1400 Music Fundamentals</td>
<td>4</td>
</tr>
<tr>
<td>IHSS-1960 Suggested Courses:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art, Technology and Society</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>or Visualization and Creativity</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1500 Calc. I for H&amp;SS</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS-2010 Intermediate Video*</td>
<td>4</td>
<td>ARTS-2020 Computer Music*</td>
<td>4</td>
</tr>
<tr>
<td>ARTS-2540 The Multimedia Century*</td>
<td>4</td>
<td>ARTS-2030 Net Art*</td>
<td>4</td>
</tr>
<tr>
<td>ARTS-2040 Intermediate Digital Imaging*</td>
<td>4</td>
<td>Math/Science Elective</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
<td>Humanities Elective</td>
<td>4</td>
</tr>
<tr>
<td>(or CSCI-1010 Intro to Computer Programming)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional History/Theory Elective</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional Elective in Studio</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humanities/Social Science Elective</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math/Science Elective</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professional History/Theory Elective</td>
<td>4</td>
<td>ARTS-4710 Technical Production and Documentation</td>
<td>4</td>
</tr>
<tr>
<td>Professional Elective in Studio</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Humanities/Social Science Elective</td>
<td>4</td>
<td>Professional Elective in Studio</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Elective</td>
<td>4</td>
<td>Social Science Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Math/Science Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTS-xxxx Senior Capstone</td>
<td>4</td>
<td>ARTS-xxxx Senior Capstone</td>
<td>4</td>
</tr>
<tr>
<td>Professional History/Theory Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Humanities/Social Science Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

* These courses may be taken in any order.

** These courses may be taken in reverse order.
Information Technology—Arts Curriculum

The Information Technology degree with a second discipline in Arts presents an exciting program of study that emphasizes the creativity of studio arts in shaping and influencing information technology. The program extends the activities of the Integrated Electronic Arts at Rensselaer (iEAR) studios, an extensive state-of-the-art facility dedicated to interdisciplinary research and artistic development in interactivity, digital video, computer imaging, digital audio, animation, virtual reality, web design, multimedia installation, and performance art. A series of courses is designed to give students hands-on experience with a full range of arts practice within Rensselaer’s unique technological environment. Intermediate and advanced courses offer the opportunity to focus on a specialized research area and develop innovative collaborative projects. This study in the Arts second discipline provides both the theoretical foundation and practical experience needed for the many fast-growing digital arts and media careers.

Electronic Media, Arts, and Communication (EMAC) Curriculum

This joint B.S. degree is earned from both the Department of the Arts and the Department of Language, Literature, and Communication. As such, it is interdisciplinary in nature and is therefore described in detail under the heading Interdisciplinary Programs and Research at the end of the Humanities and Social Sciences section of this catalog.

Minor Programs

Music

A music minor consists of 16 credits from the music curriculum. All music minors must take ARTS-2400 Music Theory I. The remaining credits may be filled by courses in music history, theory, jazz, electronic music, world music, and performance ensembles. Up to eight ensemble credits may be applied toward the music minor.

Studio Arts

A studio arts minor consists of 16 credits from the studio arts curriculum, which includes courses in drawing, painting, and sculpture. All studio arts minors must take at least three studio courses, and at least one of these must be at the 4000 level. The remaining four credits may be filled by another studio course or an art history course.
Electronic Arts
An electronic arts minor consists of 16 credits from the electronic arts curriculum. These should include at least one or two Media Studio courses (ARTS-1010 or ARTS-1020), one art history or theory course, and one or two 2000-level or 4000-level electronic arts studio courses.

Special Undergraduate Opportunities
Visiting Artists Series
The Department of the Arts supports the iEAR Presents! series which brings leading composers, performers, and media artists to campus for performances, exhibitions, lectures, and workshops. All students are encouraged to attend the rich variety of events both on campus and in the Troy area.

Ensembles
Many noncredit ensembles, dictated by student interest, are available on campus. Typical examples have included symphonic band, jazz ensemble, swing band, percussion ensemble, and vocal groups such as the Rensselyrics and the Rusty Pipes.

Graduate Programs
Master of Fine Arts in Electronic Arts
The M.F.A. program is designed for students pursuing artistic and academic careers emphasizing electronic media. Admission is highly competitive, and applicants must have completed a bachelor’s degree and display a high level of ability in any artistic medium. In addition to the standard transcripts, recommendations, and background and goals statements, prospective students submit a portfolio of creative work. The primary consideration in the selection process is evidence of talent and commitment to personal development as a creative artist.

The M.F.A. degree requires 60 credit hours of coursework at Rensselaer, including up to nine credit hours of master’s thesis. Completion of the degree generally takes two and a half to three years. Independent creative work done under a faculty mentor’s supervision makes up the program core. The form of this creative work may include musical compositions and performances, videotapes and installations, multimedia presentations, performance art, and computer-generated or mediated images. The student’s work at Rensselaer culminates in a required thesis project, which is a major artistic effort and may include a full-length performance, installation, exhibition, submission of written thesis document, and a thesis defense.

All students are expected to develop competency in using various media available in the iEAR Studios as well as in the theoretical and critical issues relevant to their fields of interest. Since the program is geared towards preparing students to participate actively in the art and music communities, practical aspects of production and presentation of creative work are emphasized.

The historical and critical aspects of the curriculum are covered as an integral part of the studio courses, as well as in seminars on electronic arts theory and related critical theory seminars offered in other departments.
The M.F.A. plan of study consists of 60 credit hours beyond the bachelor's degree\(^1\), including:

- at least 30 credit hours in 6000-level courses
- three art or music history or theory courses at the 4000 or 6000 level, including:\(^2\)
  - ARTS-6110 Electronic Arts Overview
    - One course offered within the department
    - One course offered outside the department
- a demonstration of competency in interdisciplinary electronic arts\(^3\)
- four credits of Technical Production and Documentation (ARTS-4965)
- four credits of artistic residency through Arts Practicum (ARTS-4050)
- enrollment in Electronic Arts Practice or Thesis every semester of residency\(^4\)
- one to nine credits of Master’s Thesis
- required public presentation and participation in critiques at the end of each semester

### Course Descriptions

Courses related to all Arts curricula are described in the Course Descriptions section of this catalog under the department code ARTS.

---

\(^1\) Individual requirements can be waived, in exceptional circumstances, by the department without decreasing the total number of credits for the degree. It is also possible to reduce the total number of credits required by transferring up to 6 credits of previous graduate work or by waiving up to 12 credits for professional experience, up to 6 credits of which can be graduate transfer credit.

\(^2\) History/theory courses may be either 4 credits (4000-level courses) or 3 credits (6000-level courses).

\(^3\) Competency is demonstrated through two qualifying reviews. Each student will select two end-of-semester departmental critiques, which will be judged by the Electronic Arts Faculty Review Committee. The first review will identify the technical and creative areas to be addressed in the second review. The Committee must agree that the student’s work shows competency and artistic merit in interdisciplinary media in order for the student to progress toward his or her final thesis by enrolling in Thesis supervision credits rather than Arts-6080.

\(^4\) All levels of Arts-6080 and Thesis supervision meet together in a weekly three hour seminar format, which is required of all students in residence. When enrolled for Thesis credits, students will also be expected to have regular individual meetings with their advisers. In their final two to three semesters of residency, students must enroll in a minimum of six thesis credits. The maximum number of thesis credits in which a student can enroll is 9.
Cognitive Science

Chair: Selmer Bringsjord

Director, Minds and Machines Program: Rensselaer’s Undergraduate Program in Cognitive Science: Bram van Heuveln

Director, Graduate Program in Cognitive Science: Wayne D. Gray

Director, Undergraduate Advising, Philosophy: Michael J. Zenzen

Director, Undergraduate Advising, Psychology: Brett R. Fajen

Department Home Page http://www.cogsci.rpi.edu

Cognitive Science is broadly defined as the study of the mind/brain, how it is structured, how it functions, and how it can be represented and simulated. It is theoretically grounded in cognitive psychology, neuroscience, logic, and philosophy of knowledge and mind. Its practical applications include artificial intelligence, cognitive engineering and human factors, cognitive modeling, industrial/organizational psychology, perception and action, and psychopharmacology.

At the graduate level, the department is committed to the concept of integrated cognitive systems (ICS). Specifically, research and teaching falls into areas that together cover low- to high-level cognition, whether in minds or machines:

- Reasoning (Human and Machine)
- Computational Cognitive Modeling
- Cognitive Engineering
- Perception and Action

Modern research facilities, including the CogWorks Lab, Human Abilities and Learning Laboratory (HAL), Interactive and Distance Education Assessment (IDEA) Laboratory, Rensselaer Artificial Intelligence and Reasoning Laboratory (RAIR Lab), Vision and Action Lab, and dedicated space in the Institute’s new Social and Behavioral Research Laboratory, provide a new expression of the Department’s interests in cognitive science that integrates the diverse research activities of the faculty in the Department. An important overall goal of the Department’s programs at the graduate level is to prepare its graduates for careers as researchers in four related areas within cognitive science, including cognitive human factors, reasoning and decision-making processes, cognitive modeling, and perception and action.

Pending State approval, Rensselaer’s Cognitive Science Department will start its new Ph.D. in Cognitive Science, in the fall of 2003. For information and guidance about applying to this new Ph.D., please contact Betty Osganian, Student Program Coordinator at the undergraduate and graduate levels at osgane@rpi.edu or Kathleen O’Connor, Assistant Dean, Enrollment Management at oconnk2@win.rpi.edu.

At the undergraduate level, the Department has maintained separate programs in philosophy and psychology leading to the Bachelor of Science degree in each discipline, respectively. An important goal of the undergraduate program, particularly for those enrolled in the Minds and Machines Program, the department’s undergraduate program in cognitive science, is to prepare students for careers in the rapidly growing “Information Economy.”
Research Innovations and Initiatives
Graduate training in Cognitive Science emphasizes research, modeling, and building of integrated cognitive systems. Within this broad scope the department has special strength in the following areas.

Human and Machine Reasoning
Foci include logic-based and knowledge-based AI, theorem-proving, and psychology of reasoning. The multi-disciplinary group of researchers involved is known as the Rensselaer Reasoning Group, which works out of the Rensselaer AI & Reasoning (RAIR) Lab. For information, contact Selmer Bringsjord via selmer@rpi.edu.

Computational Cognitive Modeling
Understanding an integrated cognitive system can be very complex. The possibilities for interaction among cognitive, perceptual, and action operations is astounding. The interplay of each of these with the other and with the external world cannot be simply predicted. Computational cognitive models provide a vehicle to manage this complexity with the goal of making progress towards understanding how integrated cognitive systems effect and are affected by their environment.

Cognitive Engineering
Cognitive Engineering is the application of cognitive science theories to human factors problems. Putting cognitive theories to the test of real-world applications is a means of keeping focused on the truly important cognitive issues. At Rensselaer, cognitive engineering has two components; (a) research directed at solving applied problems, and (b) research directed at developing engineering tools that others with less cognitive training can use to solve applied problems.

Perception and Action
This area of research focuses on perception with an emphasis on its role in the performance of both routine and skilled goal-directed action. Current research topics include visually guided locomotion in real and virtual environments, the coordination of eye and hand movements, and the integration of perception and action with higher-level cognition (e.g., learning and attention). At Rensselaer, these topics are investigated from various theoretical perspectives, including ecological psychology, dynamical systems theory, and computational cognitive modeling.

Industrial and Organizational Psychology (Psychology)
The foci of this department research area include organizational training, leadership, motivation, performance evaluation, employee selection, organizational behavior, trust and honesty in the workplace, video and e-mail surveillance issues, job attitudes, negotiation and organizational conflict, and legal and labor relations issues.

Faculty*
Professors
Baron, R.A.—Ph.D. (University of Iowa); industrial/organizational psychology, social psychology.
Bringsjord, S.—Ph.D. (Brown University); logic and artificial intelligence, foundations of artificial intelligence and cognitive science, computational creativity.
Gray, Wayne D.—Ph.D. (University of California at Berkeley); interactive behavior, computational cognitive modeling, cognitive science.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Koller, J.M.—Ph.D. (University of Hawaii); Asian and comparative thought, social philosophy, philosophy of religion.

Puka, W.J.—Ph.D. (Harvard University); ethics, cognitive-moral psychology, and applied cognitive science.

Rea, M.S.—Ph.D. (Ohio State University); visual psychophysics, lighting.

Reid, L.D.—Ph.D. (University of Utah); physiological psychology of reinforcement, drug and alcohol addiction.

Wallace, W.A.—Ph.D. (Rensselaer Polytechnic Institute); decision processes and cognition, decision support systems, improvisation, visualization and modeling.

Watt, J.—Ph.D. (University of Wisconsin-Madison); survey research via the internet; marketing communication; media and web cognitive processes; mathematical models of communication processes.

Zenzen, M.J., Jr.—Ph.D. (Rensselaer Polytechnic Institute); philosophy of science, philosophy of religion, aesthetics.

Associate Professors
Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology.

Noble, R.G.—Ph.D. (University of California, Berkeley); psychobiology of choice and decision making.

Stokes, A.F.—Ph.D. (Open University Milton Keynes); engineering psychology, human factors, aviation psychology, cognitive psychology.

Assistant Professors
Fajen, Brett R.—Ph.D. (University of Connecticut); visual perception, perception and action, ecological psychology, dynamical systems modeling; virtual reality.

Yang, Yingrui—Ph.D. (New York University); cognitive psychology, thinking, reasoning and decision-making, and cognitive science.

Clinical Assistant Professors
Fahey, J.T.—Ph.D. (SUNY-Albany); philosophy of science, metaphysics, epistemology, philosophy of artificial intelligence.

Hubbell, C.L.—Ph.D. (SUNY-Albany); behavioral neuroscience; psycho-pharmacology, learning.

Traver, H.—Ph.D. (SUNY-Albany); affirmative action, interactive learning, sexual harassment, industrial/organizational psychology.

van Heuveln, Bram—Ph.D. (SUNY-Binghamton); philosophy of mind, artificial intelligence, logic, computation, reasoning, and cognition.

VerWys C.—Ph.D. (SUNY-Albany); social psychology, forensic psychology.

Adjunct Faculty
Anderson, K.—Ph.D. (University of Georgia); counseling/clinical psychology.

Athanasiou, R.—M.D. (Albany Medical Center), Ph.D. (University of Michigan); medical psychology.

Luchins, A.—Ph.D. (New York University); problem solving and thinking.

Vredenburgh, A.—Ph.D. (California School of Professional Psychology); human factors, industrial/organizational psychology, safety, forensics.

Williams, K.—Ph.D. (University of Southern California); industrial/organizational psychology.

Wogalter, M.S.—Ph.D. (Rice University); warnings, risk perception, hazard communication, human computer interaction.
Undergraduate Programs

Baccalaureate Programs

Cognitive Science Program
See the “Minds and Machines program” in the Interdisciplinary Programs and Research section of this catalog.

Philosophy Curriculum
Philosophy is a search for understanding and wisdom through inquiry into fundamental questions of existence and reflection on the underlying assumptions of knowledge and action. Through inquiry and reflection, humans seek to answer the “big” questions: What is the nature of human consciousness or of reality or of human experience? What is the meaning of life? Of what does the good life consist? How are right and wrong determined?

Agreeing with Socrates that “the unexamined life is not worth living,” the department encourages students to develop their own philosophical understanding, helping them to think critically and creatively about their own experience, values, and goals. This development of a coherent and critical personal perspective provides the foundation for a full and satisfying life, for the practice of responsible citizenship, and for leadership.

Whether working toward bachelor’s degree in philosophy alone or toward a dual degree, students must complete at least 32 credit hours of work in philosophy. Each student will develop a plan of study in consultation with a departmental adviser. In their senior year, all philosophy majors must write a thesis. Preparing this thesis will give students some research experience and early training in thesis writing in the event that they pursue further study. Students will write the thesis under the guidance of a professor of their choosing or selected based on familiarity with the research topic.

Psychology Curriculum
The field of psychology uses scientific methods and procedures to study all aspects of behavior and cognitive processes. Knowledge acquired about such topics as motivation, perception, learning, memory, personality, and social interaction is of major practical value in many settings (e.g., industry, education, health care).

Through the applied focus of many of its course offerings, the department provides a wide range of practical skills and knowledge that are useful in many different employment settings. At the same time, all undergraduate psychology students are equally well prepared for graduate work.

The department’s philosophy is to provide each student maximum flexibility in devising a specific plan of study. Psychology major requirements include the completion of three basic psychology courses (PSYC-1200 General Psychology, PSYC-2310 Experimental Methods and Statistics, and PSYC-4990 Undergraduate Thesis) and the completion of at least 18 additional credit hours within the department. The latter courses are electives and students will choose them in consultation with departmental advisers.

In addition, students must complete the basic degree requirements in physical, life, and mathematical sciences. Again, students will consult with their advisers in selecting specific courses to meet these requirements in accordance with their individual interests and goals.

As is evident in the typical four-year program outlined below, PSYC-1200 General Psychology is usually taken in the first year, PSYC-2310 Experimental Methods and Statistics and PSYC-4990 Undergraduate Thesis in the third or fourth year. Due to the flexibility permitted in course selection, individual curricula may vary considerably within the framework of basic Institute degree requirements. Students are encouraged to supplement basic requirements in science and mathematics whenever feasible in order to take full advantage of Rensselaer’s education opportunities. A minimum of 124 credit hours is required to complete this curriculum.
<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1500 Calculus I (Arch/H&amp;SS)</td>
<td>4</td>
<td>MATH-1620 Contemporary Math Ideas in Soc.</td>
<td>4</td>
</tr>
<tr>
<td>or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td></td>
<td>MATH-1020 Calculus II</td>
<td></td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I *</td>
<td>4</td>
<td>CSCI-1200 Computer Science II *</td>
<td>4</td>
</tr>
<tr>
<td>[or 1st course of a science sequence]</td>
<td></td>
<td>[or 2nd course of a science sequence]</td>
<td></td>
</tr>
<tr>
<td>IHSS-1964 First Year Studies</td>
<td>4</td>
<td>PSYC-1200 General Psychology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Social Science Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Year</td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Science or Math Elective</td>
<td>4</td>
<td>Science or Math Elective</td>
<td>4</td>
</tr>
<tr>
<td>Psychology Elective</td>
<td>4</td>
<td>Psychology Elective</td>
<td>4</td>
</tr>
<tr>
<td>Humanities Elective (2000 level)</td>
<td>4</td>
<td>Social Sci. Elective (2000 level)</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Year</td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSYC-2310 Experimental Methods and Stats</td>
<td>4</td>
<td>PSYC-4990 Undergraduate Thesis</td>
<td>4</td>
</tr>
<tr>
<td>Psychology Elective</td>
<td>4</td>
<td>Psychology Elective</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>[same code 2000 level]</td>
<td></td>
<td>[same code 4000 level]</td>
<td></td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth Year</td>
<td>Credit hours</td>
<td>Spring</td>
<td>Credit hours</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Psychology Elective</td>
<td>2</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

*The science sequence may be selected, with the assistance of the student’s adviser, from among 1000-level introductory sequences in biology, chemistry, computer science, geology, or physics, including ERTH-1030, ERTH-1040. See the handout on the science core available from the School of Science.*
Dual Majors
Dual majors are available in all three (cognitive science, philosophy, psychology) department curriculum areas. These options and their respective requirements are described below.

Cognitive Science
See the “Minds and Machines Program” in the Interdisciplinary Programs, and Research section.

Philosophy
Majors that may be combined with philosophy to form a dual major include computer science, physics, mathematics, biology, architecture, and various engineering majors (e.g., computer systems engineer). These dual programs serve the needs of those students desiring to combine the virtues of a liberal arts education with those of science, architecture, or engineering to achieve an education that is practical, stimulating, and diverse.

As an example of how such dual majors are structured, a student majoring in physics and philosophy would meet the requirements of the physics curriculum and take eight courses in philosophy. Among these would be PHIL-2130 Introduction to Philosophy of Science, PHIL-4360 Philosophical Problems of Space and Time, and PHIL-4310 Scientific Revolutions. A student majoring in computer science and philosophy would meet the requirements of the computer science curriculum and take eight philosophy courses including PHIL-2140 Introduction to Logic, PHIL-4260 Philosophy of Artificial Intelligence, and PHIL-4420 Computability and Logic. For a mathematics or computer science dual major, key courses in the philosophy major would be PHIL-4380 Philosophy of Mathematics, PHIL-4420 Computability and Logic, and PHIL-4720 Metaphysics.

Psychology
Dual majors with psychology may include computer science; electrical, computer, and systems engineering; and decisions science and engineering systems. A dual major in management and psychology is also available. The Lally School of Management has established certain requirements that must be completed for this major in addition to those described above. For further information and a list of requirements for this dual major, see the Lally School of Management section of this catalog.

Minor Programs
The Department of Cognitive Science provides a variety of minor programs within its curricula. Each of these is described in detail below.

Philosophy
To complete the minor in philosophy, a student chooses a minimum of four philosophy courses, at least one of which must be at the 4000 level.

Philosophy of Science and Logic
This minor focuses on the underlying assumptions, conceptual structures, and implications of mathematical and scientific knowledge. To complete this minor, a student chooses a minimum of at least four philosophy courses, three of which must be from the following list:

- PHIL-2130 Introduction to Philosophy of Science
- PHIL-2140 Introduction to Logic
- PHIL-4260 Philosophy of Artificial Intelligence
- PHIL-4360 Philosophical Problems of Space and Time
- PHIL-4380 Philosophy of Mathematics
- PHIL-4420 Computability and Logic
- PHIL-4440 Theory of Knowledge
- PHIL-4720 Metaphysics
Philosophy of Human Values and Society
This minor emphasizes values in contemporary society. Human values in a technological society are explored through inquiries into the nature and function of art, morality, religion, and social institutions. To complete this minor, a student chooses a minimum of five philosophy courses, at least three of them from the following list:

PHIL-2300 Asian Philosophies
PHIL-2500 Bioethics
PHIL-2830 Comparative Religion
PHIL-4240 Ethics
PHIL-4300 Environmental Philosophy
PHIL-4520 Existentialism
PHIL-4570 Buddhism

Psychology
To complete the minor in psychology, a student chooses a minimum of four psychology courses, with at least one at the 4000 level.

Brain and Behavior
This minor focuses on understanding how the structure, physiology, and chemistry of the brain shape human behavior and the practical implications of this understanding for medicine, psychology, and biotechnology. PSYC-1200 General Psychology is a prerequisite for this minor, and PSYC-4320 Psychobiology is required for completion of the minor. The remaining two courses should be chosen from the following ten:

PSYC-2940 Readings in Brain and Behavior
PSYC-4110 Motivation and Performance
PSYC-4410 Sensation and Perception
PSYC-4450 Learning
PSYC-4500 Drugs, Society, and Behavior
PSYC-2960 Topics in Brain and Behavior
PSYC-4600 Cognition and the Brain
PSYC-4940 Readings in Brain and Behavior
PSYC-4960 Topics in Brain and Behavior

Community and Health Psychology
This minor covers the applications of psychology in developing the understanding people need to exert a constructive control over their own behavior and their interactions in real-world social situations. PSYC-1200 General Psychology is a prerequisite, and PSYC-4720 Abnormal Psychology is a requirement for this minor. An additional two courses should be chosen from the following:

PSYC-2730 Social Psychology
PSYC-2940 Readings in Community and Health Psychology
PSYC-2960 Topics in Community and Health Psychology
PSYC-4110 Motivation and Performance
PSYC-4340 Human Sexuality
PSYC-4440 Personality
PSYC-4500 Drugs, Society, and Behavior
PSYC-4630 Aids: Paradise Lost
PSYC-4770 Psychopharmacology and Behavior Toxicology
PSYC-4940 Readings in Community and Health Psychology
PSYC-4960 Topics in Community and Health Psychology.

Human Factors
This minor focuses on applying basic psychological principles to the interaction between person and machine. As technology becomes more sophisticated, it is critical to design equipment that optimally fits the needs and abilities of users. The prerequisite for this course is PSYC-1200 General Psychology and PSYC-2220 Human Factors in Design is required. The remaining two courses to complete the minor should be chosen from the following:

PSYC-4160 Human Factors Seminar
PSYC-4180 Selected Topics in Engineering Psychology
PSYC-4280 Human-Computer Interaction
PSYC-2940 Readings in Human Factors
PSYC-4160 Human Factors Seminar
PSYC-4370 Cognitive Psychology
PSYC-2960 Topics in Human Factors
PSYC-4960 Topics in Human Factors
Industrial/Organizational Psychology
This minor focuses on applying psychology to performance in the work place. It helps individuals develop the knowledge base needed to improve the performance of themselves and others in the work place. PSYC-1200 General Psychology is a prerequisite for this minor and PSYC-4200 Industrial/Organizational Psychology is a requirement. An additional two courses should be chosen from the following:
PSYC-2730 Social Psychology
PSYC-4110 Motivation and Performance
PSYC-2940 Readings in Industrial/Organizational Psychology
PSYC-2960 Topics in Industrial/Organizational Psychology
PSYC-4940 Readings in Industrial/Organizational Psychology
PSYC-4960 Topics in Industrial/Organizational Psychology

Perception and Action
By considering the personal and situational factors influencing social behavior, individuals choosing this minor develop techniques to enhance their social perception, decision making, group influences on behavior, and attitudes. PSYC-4410 Sensation and Perception is a prerequisite, and PSYC-4420 Perception in Action is required. Two additional courses should be selected from the following:
PSYC-2600 Moral Development
PSYC-2940 Readings in Social Psychology
PSYC-2960 Topics in Social Psychology
PSYC-4940 Readings in Social Psychology
PSYC-4960 Topics in Social Psychology

Graduate Programs
Master’s Programs
The Department of Cognitive Science offers master of science degrees in philosophy and psychology as well as a professional master of science program in Cognitive Systems Engineering. Each of these programs is described in detail below.

Master of Science in Philosophy
This program provides opportunities to reflect on a broad range of fundamental philosophical issues under the guidance of a distinguished faculty member. Through a combination of courses, small seminars, and independent study, this program’s flexible educational structure accommodates the diverse interests of both faculty and students. It offers a supportive environment that ideally prepares students for advanced graduate work leading to a Ph.D., and gives skillful guidance in reflecting on philosophical issues for the sake of personal understanding and enrichment. The small number of graduate students (faculty to student ratio is 1:1) and extensive personal contact with faculty are major advantages. Elective courses are available for graduate students in other departments.

Rensselaer’s M.S. in philosophy program centers on Minds and Machines and is designed for capitalization on the exploding demand for machine systems that interact smoothly with, and sometimes even simulate aspects of, humans. This program is also available to those with undergraduate exposure to information related areas (e.g., philosophy, logic, computer science, psychology, math, etc.) For further information, contact Selmer Bringsjord at brings@rpi.edu.

This program is also intended for students wishing to pursue advanced work in philosophy or to prepare for philosophy doctoral study. The department especially encourages applications from students whose undergraduate majors are in other fields and wish to obtain a strong foundation in philosophy at the master’s level. For such students, completion of the requirements will normally take one to two years. A student with an undergraduate major in philosophy may be able to achieve the degree in one year.
Beyond the general requirements of the Office of Graduate Education, requirements for this degree include passing an examination in one field of philosophy that the student determines jointly with department faculty. In addition, the student must submit to the department either three acceptable papers of high quality in different areas of philosophy or a six-credit-hour thesis acceptable to the department, normally in a field different from that of the examination. Foreign language is not required for this degree.

**Master of Science in Psychology**

This program provides for concentrations in industrial/organizational and human factors.

It is, however, quite flexible and can provide for other interests as well as interdisciplinary work with other Rensselaer departments.

Thirty credit hours are required to complete this degree, and the department has specific course requirements including work in statistical design and methods and PSYC-6990 Master’s Thesis, with flexibility permitted in elective selection.

**Doctoral Program**

Pending State approval, Rensselaer’s Cognitive Science Department will start its new Ph.D. in Cognitive Science in the fall of 2003. For information and guidance about applying to this new Ph.D., please contact Betty Osganian, Student Program Coordinator at the undergraduate and graduate levels at osgane@rpi.edu or Kathleen O’Connor, Assistant Dean, Enrollment Management at oconnlk2@rpi.edu.

**Course Descriptions**

Courses related to all cognitive science curricula are described in the Course Descriptions section of this catalog under the department codes PHIL and PSYC.

**Economics**

*Chair:* Donald Siegel

*Director, Ph.D. Program in Ecological Economics:* John Gowdy

*Department Home Page:* [http://www.rpi.edu/dept/economics](http://www.rpi.edu/dept/economics)

The Nobel Prize in Economic Science recognizes the rigor and analytical content of economics. The private sector also values economic analysis, and economists are widely sought as potential employees by leading financial institutions and consulting firms. At Rensselaer, undergraduate students are introduced to the key ideas of economics that revolve around scarcity of resources and the function of social institutions. They learn to make choices among alternatives in which it often is not possible to achieve all desirable outcomes.

Through a sequence of progressively more advanced courses, students learn the concepts and tools of economics as applied to a variety of public policy issues such as: growth and technological change, resource scarcity and environmental pollution, unemployment, inflation, poverty, government spending and taxation, and regulation. Primary emphasis is on the analysis of how markets perform the central economic task of allocating scarce resources among competing ends. However, several courses such as public finance, government regulation, and cost-benefit analysis focus on public-sector allocative decision making. For engineers, scientists, and managers, career choices and options are often heavily intermixed with economic problems and policies.

The basic one-term course, ECON-1200 Introductory Economics, creates an awareness of the country’s economic problems and furnishes the basic tools with which, as voting citizens, students will reach independent, rational judgments on public policy questions.
The course provides a general introduction to economic principles and institutions. It is a self-contained course and is also a prerequisite for other courses listed. However, under certain circumstances, this prerequisite may be waived.

Prospective students should also be aware that the department administers the Edward J. Holstein Memorial Award for Excellence in Economics and the Shavell-Weinman Fund. Faculty Members are also encouraged to work with undergraduates on research projects.

Research Innovations and Initiatives
At the graduate level, the training objective is to allow students to apply the body of economics knowledge and techniques to a variety of issues in academic, government, and business settings. Department faculty and students focus their research in selected areas, including environmental and ecological economics, economics of technological change, productivity analysis, cost-benefit analysis, economic regulation, and international competitiveness.

Faculty*

Professors
Duchin, F.—Ph.D. (Berkeley); input-output analysis, structural economics, ecological economics, economic development, technological change.
Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics.
Siegel, D.S.—Ph.D. (Columbia University); economics of technological change, productivity analysis, university technology transfer, corporate social responsibility.
Vitaliano, D.F.—Ph.D. (City University of New York); public finance, cost-benefit analysis, health economics.

Associate Professor
Stern, D.—Ph.D. (Boston University); natural resource economics, quantitative methods, ecological economics.

Clinical Professor
Heim, J.—Ph.D. (State University of New York at Albany); money and banking, international economics.
Jones, R.—Ph.D. (Rensselaer Polytechnic Institute); money and banking, introductory economics, econometrics.

Emeritus Faculty
Hohenberg, P.M.—Ph.D. (Massachusetts Institute of Technology); economic history, economics of technological change.

Undergraduate Programs
Rensselaer’s undergraduate major in economics differs from other programs in three important respects. First, it requires that about one-fourth of the student’s program be in mathematics and the natural sciences. Second, students must apply quantitative tools to real economic problems, notably in problem labs that employ regression, linear programming, and risk analysis. Finally, in addition to dedicated courses, students pursue various courses dealing with relevant aspects of environmental, ecological economics, and the economics of technological change.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
## Baccalaureate Programs

A major in economics requires 34 credit hours and must include the following: ECON-1200 Introductory Economics, ECON-2010 Managerial Economics, ECON-2020 Intermediate Macroeconomics or ECON-4130 Money and Banking, ECON-4570 Introduction to Econometrics or ECON-4120 Quantitative Analysis, and ECON-4900 Seminar in Economics. An approved course in Statistics is a prerequisite to the Quantitative Analysis and Econometrics requirement.

Although specific courses will vary, the template below illustrates a typical bachelor of science curriculum within the Department of Economics. This curriculum requires a minimum of 124 credit hours.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Option I ................................4</td>
<td>ECON-1200</td>
<td>Introductory Economics ................................4</td>
<td></td>
</tr>
<tr>
<td>First Year Studies ................................4</td>
<td>ECON-1200</td>
<td>Science Option II ................................4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
<td>Hum. or Soc. Sci. Elective ..................4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON-2010</td>
<td>Managerial Economics ....................4</td>
<td>ECON-2020</td>
<td>Intermediate Macroeconomics ..........................4</td>
</tr>
<tr>
<td>Statistics Option ..................................4</td>
<td>Economics Elective ..........................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
<td>Computer Science Elective ..................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective ............................................4</td>
<td>Statistics Option or Elective ................4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON-4120</td>
<td>Quantitative Analysis ....................4</td>
<td>ECON-4570</td>
<td>Econometrics .........................................4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
<td>Economics Elective ..........................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective ............................................4</td>
<td>Hum. or Soc. Sci. Elective ..................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective ............................................4</td>
<td>Elective ........................................4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics Elective ..............................4</td>
<td>ECON-4900</td>
<td>Seminar in Economics ..........................2</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective ..........................4</td>
<td>Economics Elective ..........................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electives ...........................................8</td>
<td>Hum. or Soc. Sci. Electives ..........................6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

1. Science options are CHEM-1100, CHEM-1200, PHYS-1100, PHYS-1200, ERTH-1030, ERTH-1040. Other sequences may be substituted with approval.

2. This is a special section of this course for H&SS students, MATH-1010 may be substituted for MATH-1500.

3. As required.

4. Special version of this course for H&SS majors.

5. Degree completion may require more credits.
Concentrations
Work in the major field can easily be combined with meaningful concentrations of study in other fields of interest. Some possibilities include:

- Emphasizing liberal electives in, for example, a prelaw program or policy studies related to science and technology;
- Pursuing a minor concentration of 15 to 18 credit hours in a related professional field, such as environmental or transportation engineering, management, or computer science.

Dual Major Programs
Students are encouraged to consider a dual major as a means of enhancing their employment and graduate school prospects. Training in economics can provide an edge in either situation. A dual major is NOT a double degree, which requires 30 additional credits beyond the first degree. Dual majors may use their economics courses to fulfill the social science portion of the 24-credit H&SS Core. Otherwise the requirements are the same as for the single major in economics.

The department also offers two specially designed dual major options that uniquely combine economics with programs emphasizing science and technology and environmental issues. These include Ecological Economics, Values, and Policy and Environmental Studies, which, as programs that cross disciplines or even schools, are included in the School’s Interdisciplinary Programs and Research section found at the end of the H&SS portion of the catalog.

Minor Programs
At least 16 credit hours are required to complete an economics minor. These must include ECON-1200 Introductory Economics and ECON-2010 Managerial Economics. All courses must be taken for a grade to count towards the minor (or major). For further information on minors in economics, contact Donald Vitaliano, Sage 3405, vitald@rpi.edu, ext. 8093 or John Heim, Sage 3410, heimj@rpi.edu, ext. 8096.

Special Undergraduate Opportunities
Accelerated Programs
In consultation with an academic adviser, a student may design a five-year program to complete requirements for the Bachelor of Science in Economics and the Master of Science in Operations Research and Statistics or the Master of Business Administration. Participation in these programs may require admission to the Office of Graduate Education. They are designed to prepare the student for employment or for advanced graduate or professional training.

Graduate Programs
The Department of Economics offers a Master of Science degree aimed at developing skills in economic analysis and an interdisciplinary Ph.D. in Ecological Economics. These programs stress important applications in industry, government, and education.

Graduate level research projects cover a wide range of economic issues, including energy and environment; technological change and productivity measurement, cost-benefit analysis, health economics, international competitiveness, community sustainable development, the role of technology as an agent of change in the structure of national output in planned and market economies, global economic cooperation, cost-benefit analysis of state and local projects and policies, urbanization and industrial development; the economics of new technologies in nonprofit hospitals, technological change in input-output analysis, and innovation and international trade.
**Master’s Programs**

Though students must become competent in certain fundamental areas such as economic theory and econometrics, programs in economics are quite flexible and can readily accommodate those wishing to combine a graduate-level major in economics with a minor concentration in some related area. An economics minor can also be developed to complement a graduate program in another discipline.

**Master of Science**

Applicants for the M.S. in Economics program should have completed a bachelor’s program at an approved institution with basic undergraduate courses in economics and mathematics, including calculus. Some background in statistics is strongly recommended. Candidates must complete 24 credit hours of course work selected in consultation with the program adviser, submit a six-credit thesis, and pass a comprehensive oral examination. There is no foreign language requirement.

**Professional Masters Program in Ecological Economics, Values, and Policy**

The Departments of Economics and Science and Technology Studies (STS) jointly offer this program, which builds on Rensselaer’s nationally recognized expertise and course offerings in the economic, political, social, cultural, and ethical implications and interactions of science, technology, environment, and society. EEVP targets early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector, for example, professionals in environmental NGOs (non-government organizations) who wish to upgrade their skills and advance their careers. Building on required courses in environmental, ecological, and natural resource economics and in environmental philosophy and policy, EEVP helps students acquire skills such as policy analysis and ecological valuation. These skills are necessary to address the complex multidisciplinary problems any society faces in such areas as environment and health, appropriate technology, and sustainable development. The 21st century promises a continuation of the march toward globalization. Dealing with prospects and problems of a world economy and the growing human impact on the natural world requires a broad and deep education. EEVP offers “hands-on” training that puts into practice the slogan “think globally, act locally.”

For more detailed information on the EEVP Master’s Program, see the Interdisciplinary Programs and Research section of this catalog.

**Doctoral Programs**

The Economics Department offers an interdisciplinary Ph.D. degree in ecological economics with cooperation from the Departments of Science and Technology Studies, Biology, and the Environmental Management and Policy Program in the School of Management.

This Ph.D. program allows for individual research specialization and independent study in an atmosphere of close contact between faculty and students based on research participation. Ecological economics is an interdisciplinary field involving economics, ecology, and social theory. Students take basic theory courses in micro- and macroeconomics and econometrics, as well as course sequences in the advanced fields of ecological economics and public sector economics. Beyond the required work in theory and quantitative methods, students can choose an elective field for advanced study and dissertation research. Students may choose other advanced courses from offerings within the Departments of Biology, Science and Technology Studies, and other Rensselaer departments that meet students’ interests.

The Ph.D. in economics requires 90 hours beyond the baccalaureate degree and 60 hours beyond an M.A. or M.S. in economics or a related field. This requirement entails a minimum of 30 hours of course work or 10 three-credit courses. However, most students will choose to take more courses and may be required to do so if their background so indicates. Thesis credit will vary between 15 and 30 hours.
Students must complete core courses in microeconomics, macroeconomics, and quantitative methods. In addition, two of the following three courses are required: ECON-4230 Environmental Economics, ECON-4250 Ecological Economics, and ECON-4240 Natural Resource Economics. The rest of the program is chosen around other advanced courses in economics, biology, environmental management, philosophy, science and technology studies, or environmental engineering. Students are also encouraged to attend seminars conducted regularly in the economics department as well as in other Rensselaer departments, e.g., science and technology studies and biology.

Immediately upon entering the economics Ph.D. program, students should draft a study plan. These plans must be kept current, as they will likely undergo periodic changes. The program director or co-director must approve the plan of study.

Economics Ph.D. students must also pass written qualifying exams that cover theory and application in the three required core fields. Exams are offered twice a year. The examining faculty will prepare study questions and a list of related readings for students planning to take the required exams in microeconomics, macroeconomics, and quantitative methods.

Upon successfully completing the qualifying exams, students organize a thesis committee for their dissertation. One member of the required four-person committee must be from outside the economics department. The student will prepare a dissertation prospectus that covers the theoretical and applied literature in the chosen field of study for the dissertation and outline the planned dissertation research. The prospectus presentation constitutes an additional oral field exam in a chosen area of specialization.

**Course Descriptions**

Courses related to all economics curricula are described in the Course Descriptions section of this catalog under the department code ECON.

**Language, Literature, and Communication**

Chair: James H. Watt

Department Home Page: [http://www.llc.rpi.edu/](http://www.llc.rpi.edu/)

The Department of Language, Literature, and Communication (LL&C) is an internationally-recognized center for interdisciplinary education, research and theory development. The department’s programs span areas including Human-Computer Interaction (HCI), composition and writing, computer-mediated communication (CMC), foreign languages, graphics and visual communication, literature and cultural studies, rhetoric, and technical communication.

The department offers a B.S. in Communication, including a concentration in Web Design and Analysis (Web D&A); M.S. programs in Technical Communication, including a concentration in Human-Computer Interaction, and in Communication and Rhetoric, and a Ph.D. in Communication and Rhetoric. Also offered in partnership with the Department of the Arts is a B.S. in Electronic Media, Arts, and Communication (EMAC). Through another partnership with the Faculty of Information Technology, LL&C offers a B.S. in Information Technology (IT) with Communication as a concentration. The M.S. program in Technical Communication is available through Rensselaer’s distance education program as well as on campus.

The B.S. programs prepare students for advanced study or for employment in fields related to communication technology, strategic communication, technical communication, multimedia production, and careers in the emerging Internet technologies. The M.S. degrees can lead to careers as information archi-
tects, Web-designers, multimedia specialists, graphic designers, electronic communication specialists, technical communicators, usability engineers, and instructional interface designers. The M.S. programs also provide a foundation for doctoral study. Ph.D. graduates in Communication and Rhetoric find careers in business and government as well as in academia. The growing need for persons who understand the new communication technologies, and their impact on society and individuals, creates a demand for all LL&C program graduates.

Undergraduates may use some of their elective courses to complete a Certificate in Communication Design. Certificate programs in either Graphics or HCI are available to graduate students. Graphics or Communication Design can provide special competency in Visual Design and Communication. The HCI certificate provides special competency in the design and analysis of computer-user interfaces. Either graduate certificate program can be incorporated into a standard M.S. program plan of study. The program in HCI is available via distance education and is an option in the M.S. in Management and Technology as well as in the M.S. in Technical Communication.

Research Innovations and Initiatives
In research, the department's mission is to develop and assess new understandings of how people create and manage their social and professional worlds through the mediation of symbol systems and communication technologies. The major thrusts of department research are described below.

Communication and Computers
Research in this area focuses on technology-mediated communication, design of human-computer interactions, information technologies in community development and networking, and technical and professional communication practices.

Rhetoric, Culture, and Communication Technology
Specific research projects in this area include cultural studies of film, photography, advertising, and cyberspace; the history and theory of rhetoric; and language in collaborative design work. Also underway is research in cultural rhetoric, which includes ethnographic studies of themed cultural environments.

Media Design and Theory
Design of hypermedia text and artwork, writing for print and digital media, visual communication and design, and the integration of visual with verbal codes are current areas of research in this category.

Research Facilities
To support these programs, LL&C maintains a variety of research-centered laboratories and facilities:

- Human-Computer Interaction Laboratory-Situated in 4303 Sage Lab, the HCI Laboratory fosters interdisciplinary research and development. Ongoing projects include usability research, online support of physical performance, technological support for collaborative work, and community networking. The laboratory is equipped with computer workstations and video equipment for recording and analyzing human-computer interactions.
- LL&C Conference Circle-Located in 4305 Sage Lab, this technology-supported conference room is available by reservation to department students, faculty, and staff. Developed with funding from the National Science Foundation, NYNEX, and Intel, the Conference Circle provides three Pentium workstations linked to each other and to the campus network. Large screen monitors buried in the Conference Circle surface allow groups to view, discuss, and alter common work.
- Design Conference Room-Located in Low Center for Industrial Innovation, 3211, this conference room facility integrates electronic and face-to-face interaction. Funded by the National Science Foundation,
the Design Conference Room provides support for intellectual teamwork through individual private systems networked to a common public system. Reconfigurable Collaboration Network© software permits participants to take turns controlling sessions on the public system, working together on common projects. The Design Conference Room is available to department faculty and student teams by reservation. For more information about the DCR access http://www.dcr.rpi.edu.

■ Intel Laboratory-Students in LL&C and in the EMAC program have access to the Intel Lab in 4711 Sage Lab for both classes and individual work. The laboratory contains Pentium workstations with expanded memory and a variety of peripherals, all connected to the campus network via Ethernet. Printers, scanners, and digital cameras are also available. The laboratory also offers software packages from Adobe, Macromedia, and Microsoft. Additional software includes Cosmo Worlds, Extreme 3-D, SoftImage, QuarkXPress, RoboHelp, Chinese Word Processing, and a variety of browsers. More information on the Intel Lab is available by calling ext. 6467.

■ Writing Center-This tutorial service available to all Rensselaer students offers help in all areas of writing such as lab reports, research projects, papers, proposals, reports, formal letters, and resumes. Students receive instruction from expert staff on a one-to-one basis. Attendance is voluntary, and no appointment is necessary. Students can also arrange more formal programs of writing improvement. Hours are posted at the center in 4508 Sage Lab. Additional information about the center’s resources (including on-line publications) can be accessed on its web site at http://www.rpi.edu/web/writingcenter/.

■ Collaborative Classroom-Drawing on previous work in the Rensselaer Design Conference Room, the Collaborative Classroom, funded by the National Science Foundation and NYNEX and located in 2015 Troy Building, supports intellectual teamwork in the classroom. It provides teams of laptop users with the technological support required to generate, coordinate, and refine the joint action required in collaborative design. Furnished with technology-enhanced conference tables, the Collaborative Classroom provides across-the-table seating for seven teams of six students each.

■ Social and Behavioral Research Laboratory (SBRL)-Contained herein are applied and basic research in computer-mediated communication (CMC), human-computer interaction (HCI), psychology, cognitive science, community informatics, and technology studies. Faculty and graduate students from the Departments of Language, Literature, and Communication; Cognitive Science; Computer Science; Electronic Arts; Management; and Science and Technology Studies conduct cross-disciplinary studies in the social and behavioral impact of information technologies. The 10,000 square foot lab contains HCI and human factors research suites with eye gaze and observational video systems, focus group rooms with both direct and video observation and recording facilities, small CMC research rooms with computer and video systems, an immersive virtual reality studio, a computer-aided telephone and Web survey research lab, and a large-group research room. The SBRL is located in the newly renovated Gurley Building, which is listed in the National Registry of Historic Buildings, in downtown Troy adjacent to the Rensselaer campus.

Faculty*
Professors
Geisler, C.—Ph.D. (Carnegie-Mellon University); writing in workplace and professional contexts; the intersection of text, technology, and design; methods of the analysis of verbal data; genre theory; academic literacy.
Krull, R.—Ph.D. (University of Wisconsin-Madison); electronic user interfaces and performance support; training and documentation for physical skills; usability research design.

*Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Nadel, A.—Ph.D. (Rutgers University); literary theory and cultural narrative; American cultural studies; film and television studies; African-American studies; modern and contemporary American literature; creative writing.

Odell, C. L.—Ph.D. (University of Michigan); composition theory and research; integrating visual and verbal information; writing in nonacademic settings; rethinking “literacy”; education reform.

Watt, J.—Ph.D. (University of Wisconsin-Madison); survey research via the Internet; marketing communication; media and web cognitive processes; web communication technologies; mathematical models of communication processes.

Whitburn, M.—Ph.D. (University of Iowa); history and teaching of technical communication; history of rhetoric, rhetoric bibliography; history of English studies; web design.

Associate Professors
Burke LeFevre, K.—Ph.D. (Rensselaer Polytechnic Institute); rhetorical invention; social aspects of rhetoric and communication, particularly relating to the fields of medicine and intellectual property law; curriculum design for teaching writing in all disciplines; scholarship and pedagogy of electronic portfolios.

Deery, J.—D.Phil. (Oxford University); media studies; television and new media; advertising and culture; popular culture; utopian literature; literature and science.

Esrock, E. J.—Ph.D. (New York University); cognitive/neuropsychological approaches to literature and art; theory of literature, art, and photography; modern literature; women writers.

Gordon, T.—Ph.D. (University of California-Berkeley); cultural anthropology; religion and globalization; sociolinguistics; ethnographic methods; themed environments; popular/public culture; Polynesia and the United States.

Search, P.—M.A. (Goddard College); visual design theory and practice; computer-generated imagery and graphics; computer animation and hypermedia; user interface design for hypermedia programs.

Zappen, J. P.—Ph.D. (University of Missouri); community networking; participatory-design processes; rhetoric and writing; web-design theory and research.

Clinical Associate Professors
Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability; human-computer interaction; communicating on the WWW; usability testing and evaluation; analysis of computer-games interfaces; effective teaching and learning in the virtual classroom.

Hübscher-Younger, T.—Ph.D. (Auburn); Computer-supported collaborative learning; educational technology; human-computer interaction; usability evaluation; software engineering; web application and interface design and development.

Clinical Assistant Professors
Gerber, L. R.—Ph.D. (University at Albany, SUNY); scientific French; electronic media; computer-mediated communication in France: the concurrent development of the Minitel and Internet in France and the Francophone countries.
Gutmann, J.—D.A. (University at Albany, SUNY); creative writing (poetry and poetics); myth and language; environmental ethics and literature; Native American literature; Asian philosophies and religions; world religions.

Miyamoto, P.—M.F.A. (Otis Art Institute); visual design theory; publication design theory and practice; exploration of paint-based medium as an expressive art form.

Lecturers

Marko, M.—M.A. (University of Oregon); German language pedagogy, Internet in German-speaking Europe, Green movement, literature and the arts, film studies, 20th century German literature and culture, Romanticism.

Shen, T.—M.A. (Chinese Academy of Social Sciences); M.A. (University of Massachusetts- Amherst); Chinese linguistics, dialectology, phonology, and general linguistics.

Undergraduate Programs

All LL&C undergraduate programs provide students with the multidisciplinary education essential for leadership in an “information society.” Rapidly transforming this society are new communication processes and technologies. Building on Rensselaer’s strong technological infrastructure, these programs offer hands-on education in the new communication technologies and theoretical frameworks to understand and shape the cultural impact of these technologies.

Baccalaureate Programs

Communication (Comm) Curriculum

The B.S. in Communication requires a total of 124 credit hours, including 44 credit hours of major requirements. Of the remaining credit hours, 32 are free electives, 24 meet Rensselaer requirements in the humanities and social sciences, and 24 are taken in math, science, and computing.

B.S. in General Communication

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credit hours</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>IHSS-1966 (COMM-1510) Introduction to Communication Theory ..........4</td>
<td>LITR-2110 Introduction to Literature ..........4</td>
</tr>
<tr>
<td>WRIT-2110 Rhetoric and Writing ..........4</td>
<td>COMM-2610 Introduction to Visual ..........4</td>
</tr>
<tr>
<td>MATH-1500 Calc I for H&amp;SS ..........4</td>
<td>Hum. Elective/First-Year Studies ..........4</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credit hours</strong></td>
<td><strong>Credit hours</strong></td>
</tr>
<tr>
<td>Major Requirement 1 ............4</td>
<td>Major Requirement 1 ............4</td>
</tr>
<tr>
<td>Social Science Elective ............4</td>
<td>Hum./Soc. Sci. Elective ............4</td>
</tr>
<tr>
<td>Math/Science Elective ............4</td>
<td>Math/Science Elective ............4</td>
</tr>
<tr>
<td>Free Elective ............4</td>
<td>Free Elective ............4</td>
</tr>
</tbody>
</table>

1 Major Requirement (44 credit hours required) All Communication majors are required to take IHSS-1966 or COMM-1510, COMM-2610, and IHSS-1969 or COMM-196X (Comm. and Info. Tech.) Students who are following the General Communications major (i.e., those who are not following the Web Design and Analysis Concentration) are also required to take LITR-2110 and WRIT-2110. The remaining 24 credit hours are comprised of courses taken from the Language, Literature, and Communication Department. Courses with the codes COMM, LANG, LITR, and WRIT fulfill the requirement.
Concentration

All communication undergraduates may choose a more specialized track or concentration, in order to fulfill a bachelor’s degree. The Web Design and Analysis (Web D & A) concentration presented above provides a curriculum for students who want to understand how communication principles affect the design and effectiveness of the World Wide Web and related systems. The concentration prepares students to provide leadership in designing, assessing, and shaping the World Wide Web and emerging Internet technologies. After completing this sequence, students will be able to conceptualize, construct, and critique WWW communications from an intellectual and practical perspective. This concentration also develops competencies in graphics, information architecture, media assessment, and technology applications such as e-business.

In consultation with their advisers, students in the Web Design and Analysis concentration choose 12 credit hours of LL&C electives. Students are especially encouraged to use these electives to take a set of related courses, such as graphics, communication design, or human-computer interaction. A 4-credit hour Communication Internship focusing on Web design is also required.

---

1 Major Requirement (44 credit hours required) All Communication majors are required to take IHSS-1966 or COMM-1510, COMM-2610, and IHSS-1969 or COMM-196X (Comm. and Info. Tech.) Students who are following the General Communications major (i.e., those who are not following the Web Design and Analysis Concentration) are also required to take LITR-2110 and WRIT-2110. The remaining 24 credit hours are comprised of courses taken from the Language, Literature, and Communication Department. Courses with the codes COMM, LANG, LITR, and WRIT fulfill the requirement.
## B.S. in Communication (Concentration in Web Design and Analysis)

**First Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IHSS-196x (COMM 1510) Intro. to Communication Theory ..........</td>
<td>4</td>
<td>COMM-2610 Intro. to Visual Communication ..........</td>
<td>4</td>
</tr>
<tr>
<td>Hum. Elective/First Year Studies ..........</td>
<td>4</td>
<td>MATH-1620 Contemp. Math Ideas in Society ..........</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1500 Calculus I for H&amp;SS ..........</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing Requirement 1 ..........</td>
<td>4</td>
<td>Open Elective ..........</td>
<td>4</td>
</tr>
<tr>
<td>H&amp;SS Core ..........</td>
<td>4</td>
<td>H&amp;SS Core ..........</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1200 Computer Science II ..........</td>
<td>4</td>
<td>Math/Science Core 8 ..........</td>
<td>4</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Approaches to Assessment Requirement (LL&amp;C) 5 ..........</td>
<td>4</td>
<td>COMM-4300 Comm. Internship (focusing on Web Design) 6 ..........</td>
<td>4</td>
</tr>
<tr>
<td>LL&amp;C Elective 1 ..........</td>
<td>4</td>
<td>H&amp;SS Core ..........</td>
<td>4</td>
</tr>
<tr>
<td>H&amp;SS Core ..........</td>
<td>4</td>
<td>Open Elective ..........</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Core 8 ..........</td>
<td>4</td>
<td>Open Elective ..........</td>
<td>4</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Applications Requirement 7 ..........</td>
<td>4</td>
<td>LL&amp;C Elective 1 ..........</td>
<td>4</td>
</tr>
<tr>
<td>H&amp;SS Core ..........</td>
<td>4</td>
<td>Open Elective ..........</td>
<td>4</td>
</tr>
<tr>
<td>Open Elective ..........</td>
<td>4</td>
<td>Open Elective ..........</td>
<td>4</td>
</tr>
</tbody>
</table>

---

1. 12 additional credit hours in Language, Literature, and Communication Electives. Students are encouraged to take a set of related courses, such as graphics, communication design, or human-computer interaction.
2. 4 credits, Information Architecture. (COMM-4690), (WRIT-496x) (Adv. Content Dev. for WWW)
3. 4 credits, Writing Requirement. Students in the Web Design and Analysis Concentration will meet the writing requirement by taking one of the following courses. (WRIT-2110), (WRIT-1110), (WRIT-2520)
4. 4 credits, Graphics. (COMM-4650), (COMM-496x), (COMM-496x) (Visual Design, Visual Literacy)
5. 4 credits, Approaches to Assessment. Students must satisfy this requirement by taking a course that emphasizes either empirical assessment or social/critical assessment.
   A) Empirical Assessment: (COMM-4420), (COMM-4590), (COMM-4170) OR
   B) Social/Critical Assessment: Media and Popular Culture (COMM-2460)
6. 4 credits, (COMM-4300). Students must take a 4-credit hour communication internship focusing on a web design project. It is suggested that this requirement be fulfilled during the junior year.
7. 4 credits, Applications Requirement. (COMM-496x) (Web Advertising)
8. Math/Science Requirement. Required courses in of math and science are: MATH-1500, MATH-1620, and CSCI-1100 and CSCI-1200. MATH-1010 and MATH-1020 may be substituted for MATH-1500 and MATH-1620, respectively. To ensure that students have some depth in their Science core, students must take at least two courses within a single area other than Mathematics. All students must fulfill the Institute requirement of 24 credit hours of Math/Science. One-credit courses that are graded satisfactory/unsatisfactory do not satisfy science requirements. Please see departmental advisor for more information.
Electronic Media, Arts, and Communication (EMAC) Curriculum
This joint B.S. degree is earned from both the Department of Language, Literature, and Communication and the Department of the Arts. As such, it is interdisciplinary in nature and is therefore described in detail under the heading Interdisciplinary Programs and Research at the end of the Humanities and Social Sciences section of this catalog. [292]

Information Technology and Communication (IT/Comm) Curriculum
The B.S. in IT/Communication is a degree with a concentration, consisting of a 56-credit core in Information Technology and 32 credits taken in Language, Literature, and Communication (LL&C). This degree prepares students for leadership roles in careers such as communication specialists and corporate information officers. Beginning courses introduce students to the basics of communication theory, literacy theory, and written and visual communication. Students in IT/Comm should consider taking course work in one or more of the following LL&C pursuits: communication in new media, visual communication, and human-computer interaction.

All LL&C undergraduate programs strive to accommodate students’ differing academic and professional goals, while ensuring that they gain a depth of knowledge in one or more specific areas. Following are some sample programs of study:

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-1210 IT Revolution: Myth or Reality</td>
<td>4</td>
<td>ITEC-1220 Politics and Economics of IT</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
<td>CSCI-1200 Computer Science II</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>WRIT-2110 Rhetoric and Writing</td>
<td>4</td>
</tr>
<tr>
<td>COMM-1510 Introduction to Communication Theory</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Either: *</td>
<td></td>
<td>Either: *</td>
<td></td>
</tr>
<tr>
<td>ECSE-2610 Computer Components and Operations</td>
<td>4</td>
<td>ECSE-2660 Comp. Arch. Networking &amp; OS</td>
<td>4</td>
</tr>
<tr>
<td>ENGR-2961 Intro. to the HC11 Microcontroller</td>
<td>1</td>
<td>CSCI-2300 Data Structures and Algorithms</td>
<td>4</td>
</tr>
<tr>
<td>CSCI-2500 Computer Organization</td>
<td>4</td>
<td>LITR-2110 Introduction to Literature</td>
<td>4</td>
</tr>
<tr>
<td>ITEC-2210 Intro. to Human Computer Interaction</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>ITEC-2110 Exploiting the Information World</td>
<td>4</td>
<td>One of the following courses:</td>
<td></td>
</tr>
<tr>
<td>COMM-2610 Intro. to Visual Communication</td>
<td>4</td>
<td>ENGR-2600 Modeling and Analysis of Uncertainty, or</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CSCI-2300 Data Structures and Algorithms</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PSYC-2310 Experimental Methods &amp; Statistics,</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-4310 Managing IT Resources</td>
<td>4</td>
<td>ITEC-4960 Creative Design in IT</td>
<td>4</td>
</tr>
<tr>
<td>IT Elective, One of the following:</td>
<td></td>
<td>Communication, Writing, or</td>
<td></td>
</tr>
<tr>
<td>CSCI-4380 Database Systems, or</td>
<td>4</td>
<td>Language</td>
<td></td>
</tr>
<tr>
<td>DSES-4530 Information Systems</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Comm., Writing, or Lang. Elective</td>
<td>4</td>
<td>Hum./Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Science Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

*Select either the first course in both lists or the second course in both lists. Do not select the first course in one list and the second course in the other.*
Minor Programs

Students in all undergraduate degree level programs are strongly advised to develop a minor in a compatible field of interest. Participation in an internship or co-op is also recommended to allow students to gain professional work experience.

The Department of Language, Literature, and Communication offers a selection of minors for majors in other departments, all of which require at least 16 credit hours.

Communication
To complete this minor, students must take COMM-1510 Introduction to Communication Theory and one 4000-level Communication course. Two additional 4-credit communication courses under the codes COMM-XXXX or WRIT-XXXX are also required.

Literature
A literature minor must include LITR-2110 Introduction to Literature, plus three other 4-credit literature courses under the code LITR-XXXX.

French
This minor consists of four consecutive courses in French, not including French I, and requires at least one course past the French IV level.

German
Required courses for this major include LANG-1320 German II, LANG-2310 German III, and two 4-credit, 4000-level German courses. Students beginning the German sequence with German III must take three 4000-level German courses following German III. The appropriate department adviser may approve some course substitutions in order to meet individual student needs.

Graduate Programs

From founding the first graduate program in technical communication in the 1950s to receiving the Association of Computing Machinery Special Interest Group’s Diana Award in 1999 for organizational leadership in producing quality documentation to the department’s faculty receiving two national teaching awards in 2001, LL&C has been at the forefront of the field. Department faculty includes many active scholars who are winners of national awards for teaching and scholarship from technical communication professional associations. They are also members of the governing boards of these associations. In addition, department faculty members are unusually active in collaborating with corporations to improve processes both at industry work sites and in Rensselaer’s educational program.

Currently, the Department of Language, Literature, and Communication’s graduate programs consist of three master’s level degree programs, a Ph.D. in Communication and Rhetoric, and two certificate programs. Specific details of these programs are outlined below.
Master's Programs

Master of Science

LL&C offers the M.S. in Technical Communication and in Communication and Rhetoric. The Technical Communication master’s degree combines course work in theory, writing, information design, graphics, and analysis of communication systems. This program enables students to work as technical communicators and Web designers and to team with user interface or electronic performance support system designers. In addition to the core M.S. courses, the program integrates courses leading to either the certificate in Human-Computer Interaction (HCI) or the Certificate in Graphics.

The M.S. in Technical Communication with an HCI concentration combines course work in human-computer interaction with theory in allied areas such as technical communication, human factors, and computer science. Students gain a breadth of theory in these areas and applied work in design and software implementation. Compared to graduates of Information Technology and Computer Science programs, these graduates emphasize knowledge of computer usability research and interface design over implementation skills. Graduates of this new HCI-focused curriculum are prepared to work as information architects, usability engineers, interface designers, or Website managers, depending on the student’s specific course selections.

The department also offers an M.S. in Communication and Rhetoric, which emphasizes a research approach to communication problems. Drawing on the core M.S. courses, this track additionally provides knowledge of existing research findings and the capacity to conduct original research. Both humanistic and social scientific perspectives are represented. The program enables students to conduct communication research, such as product usability studies in industry and government, and prepares them for doctoral study in communication and rhetoric at Rensselaer or elsewhere.

Both the M.S. in Technical Communication and the M.S. in Communication and Rhetoric require 30 credit hours for completion. Three to six credit hours may be devoted to a thesis. There is no foreign language requirement.

Doctoral Programs

LL&C’s Ph.D. in Communication and Rhetoric prepares students for careers in both academic and nonacademic settings. Some graduates become scholars and teachers; others accept government and industry positions that require skills in analyzing and designing human communication systems and practices. In either case, the Ph.D. program graduates draw upon theory and research from multiple disciplines that are central to their work.

Communication and rhetoric doctoral students enjoy a unique opportunity to cross conventional boundaries of academic disciplines. Options include exploring relationships between communication theory and literary theory; studying written, spoken, and electronic communication in both academic and nonacademic settings; relating principles from technical writing to theory and research in cognitive psychology; exploring the relationships between verbal and visual symbol systems used in documents; and learning to use a range of methodologies including textual analysis, ethnographic observation, historical interpretation, and experimental design.

While specific programs of study vary to meet individual needs and interests, all students must complete the following:

■ three core courses: COMM-6510 Communication Theory, COMM-6240 Rhetorical Theory I, and COMM-6530 Communication Research
■ at least one additional course in research methods
■ a coherent sequence of courses within a pathway
- at least one elective course outside the department
- dissertation credits

A pathway is a coherent sequence of courses to be determined in consultation with the student’s adviser and dissertation committee, with a concentration of courses in a particular area of scholarship. The department defines three primary pathways, including:

- Communication and Computers
- Media Design and Theory
- Rhetoric, Culture, and Communication Technology.

Adviser and dissertation committee approval is also required in the case of the additional research methods and elective courses.

To complete the Ph.D. program in Communication and Rhetoric requires a minimum of 60 credit hours beyond the master’s degree. Students must pass a candidacy examination including both written and oral components, and must successfully defend a written dissertation.

**Special Graduate Opportunities**

**Graphics Certificate**
The 12-credit graduate certificate is available as a stand-alone certificate or as an option in both M.S. programs. The rapid advancement of computer graphics software for page layout, drawing, image editing, and interactive multimedia design presents communicators with a wide range of powerful design options. These technological developments create the need for communicators equally in command of words and visual imagery. The graphics program integrates design theory with in-depth studio work in design for print and electronic media including interactive multimedia design, Web design, and marketing and advertising design. In addition to graphics courses, students may pursue an internship or independent study (focused on graphics) as part of the concentration.

**Certificate in Human-Computer Interaction**
Computers are now embedded in devices ranging in size from space stations to fingernails, yet human brains must still understand their user interfaces. The Human-Computer Interaction (HCI) Certificate supplies the skills and knowledge students need to work in this new environment, which includes the Web, multimedia, wizards, agents, and still-developing technologies. The HCI certificate program consists of four 3-credit courses related to the issues found in human-computer interactions: COMM-6740 Foundations of HCI Usability, COMM-6760 Electronic Coaching Systems, COMM-6750 Communication Design for the World Wide Web, and COMM-6810 Studio Design in HCI. This certificate is available to both on-campus and distance students as either a stand-alone certificate or as an option in both M.S. programs.

**Cooperative Education**
Rensselaer’s Career Development Center operates an extensive cooperative education program. Cooperative education assignments (co-ops) usually last from three to 12 months and provide full-time employment at full-time wages in industry or government. Employers throughout the United States offer LL&C students co-op opportunities in writing, graphic design, and other communication activities. Participating students reap a number of benefits from this experience: skills and practical experience, a concrete application for their academic work, and a way to test their interest in certain types of work.

While co-op opportunities cannot be guaranteed, usually the number of companies interested in sponsoring co-ops exceeds the number of available students. Students should note that co-ops also extend the amount of time required to complete the M.S. degree. Those who seek co-ops must plan to complete required courses while they are on campus. Since a co-op assignment involves full-time work at an employment site with no opportunity for Rensselaer faculty to directly observe the student’s work performance,
students are eligible for placement only after they have matriculated in the department, spent at least a semester doing on-campus course work, and have completed COMM-6110 Writing and Editing (Technical Communication); COMM-6820 Foundations of HCI Usability (HCI concentration); and at least one additional LL&C course (such as COMM-6530 Communication Research I). International students should also be aware of the need to satisfy Immigration and Naturalization Service requirements before accepting employment in the United States.

Course Descriptions
Courses related to all LL&C curricula are described in the Course Descriptions section of this catalog under the department codes COMM, LANG, LITR, or WRIT.

Science and Technology Studies
Chair: David J. Hess
Undergraduate Adviser: David Nichols
Director of Graduate Programs: Steve Breyman
Director Professional EEVP Master's Program: Steve Breyman
Department Home Page: http://www.rpi.edu/dept/sts/

The Department of Science and Technology Studies (STS) conducts interdisciplinary teaching and research on the social aspects of science and technology. The department also provides undergraduate instruction in anthropology, history, political science, and sociology. Department faculty members are drawn from these disciplines as well as from philosophy and psychology.

Wherever individuals work and live, they must understand the ways in which all aspects of society influence, and are influenced by, science and technology. Rather than holding a divided view of science and technology verses human values and society, STS recognizes both the human dimensions of science and technology, and the scientific and technological dimensions of human existence.

Research and Innovation Initiatives
The Science and Technology Studies Department at Rensselaer Polytechnic Institute is an interconnected network of scholars, activists, and students invested in studying science and technology from multiple perspectives. The strength of the department lies in its intellectual diversity. The department has faculty members trained in and students studying the traditional disciplines of anthropology, design, geography, history, philosophy, political science, sociology, and social psychology. Theoretical approaches encompass critical policy studies, cognitive sciences, cultural theory, ethics, linguistics/semiotics, political economy, simulation/ethnomathematics, and social theory. Objects of study range from the material to artificial worlds. Research within the department has focused on the environment, health, information technology, engineering, and design. The Science and Technology Studies Department is a place where faculty and students pursue studies of power, gender, race, colonialism, and the interactions between research and activism. This matrix of disciplines, theoretical approaches, objects of study, and topical issues inform the scholarship of the department and creates an open, productive, and collaborative intellectual location from which to engage in exploring the multifaceted relationships among science, technology, and human existence.
Faculty*

Professors

Anderson-Gold, S.—Ph.D. (New School for Social Research); ethics, social and political philosophy, history of philosophy.

Capraeal, L.R.—Ph.D. (University of California, Santa Barbara); evolutionary theory; decision making, interpersonal dimensions of computing.

Hess, D.—Ph.D. (Cornell University); science, technology, and communities; nutrition and health.

Layne, L.—Ph.D. (Princeton University); medicine and culture, new reproductive technologies, popular images of nature, feminist methods.

Restivo, S.—Ph.D. (Michigan State University); sociology of science, sociological theory.

Winner, L.—Ph.D. (University of California, Berkeley); political theory, politics of technology.

Associate Professors

Breyman, S.—Ph.D. (University of California, Santa Barbara); political economy of environment, science, and society.

Fortun, K.—Ph.D. (Rice University); international politics, environmentalism, and the law.

Hannigan, J.—M.Arch. (Pratt Institute); product design, sustainable systems, history of communication.

Woodhouse, E.J.—Ph.D. (Yale University); policy of science and technology, decision making.

Assistant Professors

Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies.

Campbell, N.—Ph.D. (University of California, Santa Cruz); drugs and pharmaceutical policy, women and health, women's studies.

Eglash, R.—Ph.D. (University of California, Santa Cruz); African studies, anthropology, black history, cybernetics and virtual communities, math and science education.

Fortun, M.—Ph.D. (Harvard University); historical and ethnographic studies of genomics, biotechnology of life sciences, critical scientific literacy.

Fouche, R.—Ph.D. (Cornell University); history of American technology, theories of race and racism, African-American studies, invention, design, and intellectual property.

Vostral, S.—Ph.D. (Washington University); U.S. history, women's studies, reproductive products.

Clinical Assistant Professor

Boyer, K.—Ph.D. (McGill University); urban design; information technology; gender and work.

Lecturer

Everett, M.—A.B.D. (Erasmus University); sustainable livelihoods and sustainable development.

Phelan, T.—S.T.L (Theological College of the Catholic University of America); Institute Dean and Historian.

Adjunct Assistant Professor

Young, N.—Ph.D. (University of Chicago); entrepreneurship.

*Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Undergraduate Programs

The Department of Science and Technology Studies initiated a bachelor of science degree program in the 1985–86 academic year. Rensselaer is a leader among the many American colleges and universities that grant degrees in the field. The STS degree program—Science, Technology, and Society (STS)—is a liberal arts program that prepares students for life and work in a technoscience-based society. Some graduates will attend professional schools to study corporate or patent law, medicine, policy analysis, or the management of science and technology. Others will use the program to obtain broad exposure in the social sciences and humanities prior to committing to a single discipline for the M.S. or Ph.D. Those entering the job market directly following graduation will find a growing need in consulting firms, major corporations, and government agencies for their unique combination of technical competence and conceptual, writing, and speaking abilities. The Rensselaer STS graduate, therefore, has a distinct advantage over other liberal arts graduates.

Baccalaureate Program

The STS bachelor’s program of study requires 124 credit hours, including the standard Rensselaer 24-credit hour humanities and social sciences requirement and 24-credit hour science, math, and computing requirement. At least 32 credit hours are required within the student’s major. These must be accompanied by 16 credit hours in a technical area (the technical option) relevant to this STS Major.

The 32 credit hours usually include the following: STSH/STSS-1110 Introduction to STS, two of the 2000-level STS concentration options courses, a methods/statistics option, two of the 4000-level STS advanced options, a public service internship, and a senior project or thesis. The department chair or undergraduate adviser may allow substitutions.

Students must also satisfy the humanities and social science core program, which can be achieved through STSH courses for humanities credit and STSS courses for social sciences credit. Some STS courses are offered with the IHSS code in the first year studies program; all courses with an IHSS code may be counted for either humanities or social sciences credit.

Built into the program are several important elements. Among these is a part-time internship in a government agency or other setting where social issues in science and technology are discussed. Additional elements include skills training in computing, statistics, and research methods; strong development of speaking and writing skills; and opportunities to serve as faculty research assistants.

In cooperation with a faculty adviser, each student tailors a program of study to his or her interests. So, for example, a student interested in environmental issues can combine technical courses in environmental engineering and/or science with STS Advanced Option courses in Environment and Society (see list below). These can also be accompanied by other courses in humanities and social sciences such as ECON-4230 Environmental Economics. An internship with a New York state environmental agency and a senior project on regulation of acid rain or hazardous waste are additional possibilities for environmentally geared students.

Although specific courses will vary based on such individual interests, the template below provides a sample STS curriculum.
## Undergraduate Curriculum

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1500 Calculus 1</td>
<td>4</td>
<td>MATH-1520</td>
<td>4</td>
</tr>
<tr>
<td>STSS-1110 STS Conc. Options</td>
<td>4</td>
<td>STS Methods/Stats.</td>
<td>4</td>
</tr>
<tr>
<td>STSS-1110 Science Sequence</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Human or Soc. Sci. Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-1100 Computer Science</td>
<td>4</td>
<td>Sci. or Math Elective</td>
<td>4</td>
</tr>
<tr>
<td>STSS-4800 Pub. Serv. Internship</td>
<td>4</td>
<td>STS Technical Option</td>
<td>4</td>
</tr>
<tr>
<td>Human or Soc. Sci. Elective</td>
<td>4</td>
<td>Advanced STS Option</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS-4800 STS Technical Option</td>
<td>4</td>
<td>STSS-4980 STS Senior Project</td>
<td>4</td>
</tr>
<tr>
<td>Advanced STS Option</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Electives</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS-2100 Medicine and Society</td>
<td>4</td>
<td>STSS-2400 Law, Values, and Public Policy</td>
<td>4</td>
</tr>
<tr>
<td>Advanced STS Option</td>
<td>4</td>
<td>STSS-2550 Information, Society, and Culture</td>
<td>4</td>
</tr>
<tr>
<td>Electives</td>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Concentrations

STS offers several concentration “options” each of which is described below.

**STS Concentration options**

These are two survey courses, selected with student adviser assistance from among the following five courses, each of which represents one of the concentrations in science and technology. In addition, STSS-2500 Historical and Cultural Perspectives on Science and Technology may be included. STSS-2960 Century of the Gene* may be taken instead of STSS-2100 Medicine and Society and STSH-2960 Design, Culture, and Society* may be taken instead of STSS-2200 Engineering, Design and Society.

- **STSS-2100 Medicine and Society:** Perspectives on Science and Technology
- **STSS-2200 Engineering, Design, and Society:** Perspectives on Science and Technology
- **STSS-2300 Environment and Society:** Perspectives on Science and Technology
- **STSS-2400 Law, Values, and Public Policy:** Perspectives on Science and Technology
- **STSS-2550 Information, Society, and Culture:** Perspectives on Science and Technology

*Other mathematics options may be selected with the permission of the student’s adviser.

* The science sequence may be selected, with the assistance of the student’s adviser, from among 1000-level introductory sequences in biology, chemistry, geology, or physics, including ERTH-1030, ERTH-1040. See the handout on the science core available from the School of Science.

The science or mathematics elective that completes the core requirement in physical, life, and engineering sciences should be chosen, with the assistance of the student’s adviser, to prepare for STS Technical Options and/or other electives.

* A special topics course.
**STS Methods/Statistics Option** is one course, selected with the assistance of the student’s adviser, in either (1) research methods, (such as STSS-4130 Decision Making), a third course from among the STS Concentration Options listed above, or under special circumstances, a graduate-level research methods seminar; or (2) statistical methods, such as ENGR-2600 Modeling and Analysis of Uncertainty, ECON-4120 Quantitative Analysis, PSYC-2310 Experimental Methods and Statistics, or DSES-2010 Statistics for Management.

**Advanced STS options**
These are two related courses selected with adviser assistance from one of the following five lists, each of which represents one of the concentrations on science and technology.

**Biology, Medicine, and Society: Perspectives on Science and Technology**
- STSH-4960 Biofutures*
- STSS-4260 Sociology of Medicine
- STSS-4530 Body: Self, Symbol, and Politics

**Environment and Society: Perspectives on Science and Technology**
- STSH-4300 Environmental Philosophy
- STSS-4320 Environmental Politics and Policy
- STSS-4390 Environment and International Policy
- STSS-4400 Risky Technologies

**Law, Values, and Public Policy: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSH-4230 Engineering Ethics
- STSH-4740 Philosophy of Law
- STSH-4920 Topics in Science, Technology, and Society
- STSS-4110 Social Effects of Science and Technology
- STSS-4130 Decision Making
- STSS-4140 Inequality in America
- STSS-4270 Social Relations of Science

**Engineering, Design, and Society: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSH-4230 Engineering Ethics
- STSH-4920 Topics in Science, Technology, and Society
- STSS-4110 Social Effects of Science and Technology
- STSS-4250 Human Dimensions of Biomedical Technologies
- STSS-4270 Social Relations of Science
- STSS-4310 Politics of Science and Technology

**Information and Society: Perspectives on Science and Technology**
- STSH-4170 Ethical Issues in Computing
- STSH-4670 History of Information Technology
- STSS-4130 Decision-Making
- STSS-4310 Politics of Science and Technology
- STSS-4350 Politics of Design
- STSS-4650 Politics of Design
- STSH-4660 History of Information Technology
- STSS-4960 History of American Science
- STSS-4960 Mind, Self, and Culture*
- STSS-4960 Information Technology: Social, Legal, and Policy Issues*
- STSS-4960 AI, Robotics, and Society*

* This is a special topics course
**STS Technical options**
These four related courses are selected with student adviser assistance from among the course offerings of the Schools of Architecture, Engineering, Management, or Science (and Electronic Arts for dual majors). Students are encouraged to earn a minor or a second major through these courses or in combination with other electives. Minors can be earned, for example, in biology, computer science, environmental engineering, or science and management. The STS adviser may approve a proposal for a technical option in the School of Humanities and Social Sciences.

**Dual Major Programs**
Many STS majors choose to fulfill the requirements for a second major. For example, a pre-med student pursuing the biology, medicine, and society track within the STS major may pursue a dual major with biology, or an STS major pursuing the information and society track may pursue a dual major with computer science or information technology. There are also dozens of other dual major possibilities. There are also interdisciplinary dual major programs that have been specially developed for STS majors. These include Product Design and Innovation and Ecological Economics, Values, and Policy. For more information on these options, consult the Interdisciplinary Programs and Research section at the end of this Humanities and Social Sciences portion of the catalog.

**Minor Programs**
The STS department offers five minors, all of which are explained below. These minors generally consist of four related courses in a specialized area of study. At least two of these courses must be at the 4000-level. No Pass/Fail courses may be applied to the minor, and only one transfer or AP course may count for four to six credits. For further information on forming a minor, see the departmental adviser.

In addition to minors administered solely by the STS department, there are some interdisciplinary minor options. These include the interdepartmental minors Ecological Economics, Values, and Policy (EEVP) and Gender, Science, and Technology, and the Interschool Minor in Energy. While the EEVP minor program is outlined below, the latter program is detailed at the end of this departmental section under the heading Interdisciplinary Programs and Research.

STS department administered minors are as follows:

**Science, Technology, and Society**
All STS courses, including the first-year IHSS-1963 Science, Technology and Society*, may count toward the minor in STS, provided that the restrictions described for all department minors described above are met.

**Anthropology**
Anthropology is the study of the origins, development, and cultures of the human species. Cultural anthropology studies the full range of human societies—from tribal to complex modern societies. These studies are approached from a cultural perspective involving a community’s body of shared knowledge and understanding about the world. The anthropological perspective is multidisciplinary, comparative, holistic, and historical evolutionary.

Anthropology courses are listed under the course code STSS in the Course Descriptions section of this catalog. The following courses are those that the undergraduate director has approved for credit toward the anthropology minor.

*A special topics course.*
History

Today’s events and circumstances are a consequence of past situations and developments. As a result, understanding the present—as distinct from simply experiencing it—requires attention to history. The disciplined study of the past through written records and artifacts, as well as descriptions of witnesses, commentators, and critics, has long been part of the intellectual foundation of an educated person. History unfolds in ways that sometimes confound the expectations of both logic and predictive science, demonstrating the depth and complexity of human affairs. Thus, historical study provides valuable insight otherwise lacking in a curriculum of specialized, present-oriented branches of science and engineering. Simultaneously, historical cases present valuable evidence for social scientists or managers seeking the regularities of human events. Well-trained professionals ignore such resources at their peril.

History courses are listed in the STSH and STSS sections in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the history minor.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSH-2670</td>
<td>History of 19th Century Europe</td>
</tr>
<tr>
<td>STSH-296X/STSS 2960</td>
<td>War Since Napoleon*</td>
</tr>
<tr>
<td>STSS-2630</td>
<td>Foundations of American History</td>
</tr>
<tr>
<td>STSS-2640</td>
<td>History of the United States since 1877</td>
</tr>
<tr>
<td>STSS-2680</td>
<td>History of Contemporary Europe</td>
</tr>
<tr>
<td>STSS-2740</td>
<td>World War II</td>
</tr>
<tr>
<td>STSS-2940/STSS 4940</td>
<td>Readings in History 1860-1980</td>
</tr>
<tr>
<td>STSS-296X/4960</td>
<td>Topics in History</td>
</tr>
<tr>
<td>STSS-4610</td>
<td>Twentieth-Century Germany</td>
</tr>
<tr>
<td>STSS-4620</td>
<td>History of Medicine</td>
</tr>
<tr>
<td>STSS-4650</td>
<td>History of American Technology</td>
</tr>
<tr>
<td>STSS-4660</td>
<td>History of American Science</td>
</tr>
<tr>
<td>STSS-4960</td>
<td>History of Information Technology</td>
</tr>
</tbody>
</table>

Political Science

Political science is the investigation of how people govern themselves. This investigation encompasses both normative and empirical dimensions, i.e., the goals and purposes of politics as well as the political behavior of people as individuals and in groups. Emphasizing public policy integrates the normative and empirical aspects of political science. Social and economic questions, which always have moral and ethical dimensions, are framed as policy questions and addressed in policy decisions within the political process. Many of the department’s political science courses deal explicitly with facets of science and technology policy. The political science curriculum thus provides and excellent adjunct to professional training in science and engineering.

Political science courses are listed under STSS in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the political science minor.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS-1310</td>
<td>Principles and Practices of American Government</td>
</tr>
<tr>
<td>STSS-1330</td>
<td>International Relations</td>
</tr>
<tr>
<td>STSS-2400</td>
<td>Law, Values, Public Policy</td>
</tr>
<tr>
<td>STSS-4130</td>
<td>Politics of Science and Technology</td>
</tr>
<tr>
<td>STSS-4230</td>
<td>Environmental Politics and Policy</td>
</tr>
<tr>
<td>STSS-4330</td>
<td>World Politics</td>
</tr>
<tr>
<td>STSS-4350</td>
<td>Politics of Design</td>
</tr>
<tr>
<td>STSS-4360</td>
<td>Contemporary Political Thought</td>
</tr>
<tr>
<td>STSS-4400</td>
<td>Risky Technologies</td>
</tr>
<tr>
<td>STSS-4500</td>
<td>Environment and Development</td>
</tr>
<tr>
<td>STSS-4800</td>
<td>Public Service/Professional Careers Internships</td>
</tr>
<tr>
<td>STSS-2940/4940</td>
<td>Readings in Political Science</td>
</tr>
<tr>
<td>STSS-2960/4960</td>
<td>Topics in Political Science</td>
</tr>
</tbody>
</table>

* A special topics course.
Sociology
Sociology is the study of human interactions and social groups. It concentrates on the aspects and trends of social life that are common to all cultures: social institutions, social problems, social movements, population problems, science, medicine, and social change. The sociologist studies all aspects of social behavior—in couples; families; laboratories and operating rooms; religious, professional, and political organizations; assembly lines; and national and international contexts. This information adds a perspective for understanding human ethical problems, developing policy alternatives, and mitigating emerging social problems.

Sociology courses are listed under STSS in the Course Descriptions section of this catalog. The following course or those approved by the undergraduate director count toward the sociology minor.

- STSS-1210 Sociology
- STSS-2100 Medicine and Society
- STSS-4110 Social Effects of Science and Technology
- STSS-4140 Inequality in America
- STSS-4200 China: Past and Present

Ecological Economics, Values, and Policy
The EEVP minor combines the best of both the Economics and STS departments—incisive economic analysis and broad humanities and social science analysis that emphasize the roles science and technology play in today’s global political-economy and culture. Given the strong interdisciplinary background acquired in EEVP, graduates can play a leading role in resolving the critical environmental and social problems of the 21st century. The United Nations reports that the demand for EEVP-type program graduates exceeds the supply. According to the UN, it is crucial that we educate people who understand that “sustainable development does not merely deal with the conservation of nature or the management of ecosystems, but more broadly and fundamentally aims at new models of societal development and social transformations.”

EEVP courses are listed under ECON, STSH, and STSS in the Course Descriptions section of this catalog. The following courses or those approved by the undergraduate director count toward the EEVP minor.

Required:
- ECON-2010 Managerial Economics
- STSS-2300 Environment and Society

Choice of one of the following:
- ECON-4230 Environmental Economics
- ECON-4240 Natural Resource Economics
- ECON-4250 Ecological Economics
- ECON-4960 Topics in Economics*

Choice of one of the following:
- STSS-4300 Environmental Philosophy
- STSS-4540 Environment, Law, and Culture
- STSS-4320 Environmental Politics and Policy
- STSS-4500 Environment and Development
- STSS-4390 Environment and International Policy
- STSH/STSS-4920, 4960 Topics in Science, Technology, and Society/STS*

* A special topics course.
Gender, Science, and Technology
This gender studies minor focuses on the ways that gender influences and is influenced by science and technology. Requirements include a total of at least 16 credit hours, eight of which must be at the 4000 level. In addition, all students must take one of the 1000-level courses and the course STSS-4560 Gender Science and Technology.

1000 Level (must take at least one):
IHSS-1960 Art, Technology, and Society
IHSS-1960/STSH-1110/STSS-1110 Introduction to Science and Technology

2000 Level:

ARTS-2100 Television and Culture
COMM-2800 Interpersonal Communication
LITR-2770 Women Writers
PHIL-2500 Bioethics
PHIL-2600 Moral Development

4000 Level:

ARTS-6960 Electronic Arts Theory: Contemporary Art and Culture
COMM-4640 Language and Power
COMM-4960 Advertising and Culture
PHIL-4300 Feminist Theory
PHIL-4750 Cognition and Education

STSS-4560 Gender, Science, and Technology (required)

Students may cross-register for up to two courses in the Women’s Studies Program at Russell Sage College. Contact Linda Layne, program coordinator, at laynel@rpi.edu for more information.

Special Undergraduate Opportunities
Accelerated STS-Law Program
In cooperation with Albany Law School and Columbia University Law School, Rensselaer offers a unique program leading to the B.S. and Juris Doctor (J.D.) in six years rather than the usual seven. Admission to this program is restricted. For Albany Law School, most students are admitted as incoming first-year students. Selected applicants must meet the admission requirements of Albany Law School of Union University. Thus a prospective STS-law student may be able to assure admission to law school prior to beginning an undergraduate career at Rensselaer. Transfer from other Rensselaer curricula to this program is limited to students who have demonstrated academic excellence.

Although guaranteed admission to Albany Law School is only available to selected first-year students, conditional admission is available to accepted Rensselaer students who meet specified achievement levels in their undergraduate program. In addition Rensselaer has established a working relationship with Columbia University Law School that allows an especially gifted STS-law student to become a candidate for admission after his or her third year at Rensselaer, if nominated by a committee within the STS Department. Rensselaer’s inclusion in Columbia’s Accelerated Interdisciplinary Legal Education Program (AILE) has made this opportunity possible. Accelerated Law students have also applied successfully to such law schools as Harvard, Stanford, Cornell, and the University of Virginia for early admission. The STS Department provides whatever assistance possible for such students. Students should notify the STS undergraduate adviser before the end of the sophomore year to inform him that they wish to be nominated.

With approval of EEVP Minor Adviser, Professor Steve Breyman, ext. 8515, Sage 5207, or breyms@rpi.edu

These IHSS-1960 courses are in the First Year Studies Program

*A special topics course.
Five Year B.S.-M.S.
A five-year combined B.S.-M.S. program is available for Rensselaer undergraduates who wish to earn a graduate degree in STS. Students may apply to the program on completion of their sophomore year.

Graduate Programs
Rensselaer’s Department of Science and Technology Studies is one of the few such departments in the world to offer STS degrees from the baccalaureate to the doctoral level. Graduate programs lead to the Master of Science and the Doctor of Philosophy degrees in Science and Technology Studies. Rensselaer is committed to developing STS as a field of inquiry emphasizing the historical, political, and social dimensions of our technological society. The diverse STS faculty, drawn from a broad range of academic disciplines, provides students with the concepts and methods necessary to develop an integrated understanding of the culture’s technological and human elements.

STS faculty and graduate students are involved in a variety of research projects. Topics include careers of technical professionals, the ethnography of science, history of medicine and the role of quantification, and the nature of scientific inquiry. Additional research efforts focus on gender and reproductive technology; science, psychiatry, and religion; the politics of technological design; community impact of technological change; the impact of scientific instruments; science/government relations; and ethics and values in science and engineering.

Master’s Programs
The STS Department offers several master of science degree options, all of which are described in detail below.

Master of Science
This program is designed for students with undergraduate training in the natural and social sciences, engineering, or humanities. In addition, many entering students have substantial career experience relevant to this program.

Completing the M.S. degree in STS requires 30 credit hours, including a 6 credit hour master’s thesis or internship. Among the required core courses are STSS-6010 Concepts in Science and Technology Studies, STSS-6110 Research Methods for STS, STSS-6020 Research Seminar, and STSH-6020 Values and Policy. Also required is one additional 6000-level STS seminar (or an independent readings course with three or more students enrolled).

The program offers an opportunity to take technical courses in other Rensselaer departments that are relevant to the student’s plan of study. It also offers substantial individual consultation and flexibility in designing course work and developing the thesis/internship option. Students may use the M.S. as a professional program or as a prerequisite for doctoral studies at Rensselaer or other universities.

Five-Year B.S.-M.S
As mentioned in the department’s Special Undergraduate Opportunities section, a five-year combined B.S.-M.S. program is available for Rensselaer undergraduates wishing to earn an STS graduate degree. Students may apply to the program on completion of their sophomore year.

Master of Science/Doctor of Philosophy
Students who are enrolled in the M.S./Ph.D. program must complete a total of 90 credit hours (up to 30 in the dissertation). Students in the combined M.S./Ph.D. program are not required to take the core master’s courses, but they must take the core doctoral courses and at least one of the following capstone experiences: a research seminar (generally offered as a topics course) or an independent study course, either
of which must result in an article-length research project of publishable quality; a master’s thesis; or a master’s internship. After completing the core doctoral courses, capstone experience, and 30 credit hours, students will be awarded the degree of Master of Science in Science and Technology Studies.

**Doctoral Programs**
The STS Department’s doctor of philosophy program trains professionals for stewardship of the complex technological society as researchers, teachers, planners, and advisers in academic, government, and private institutions.

The curriculum requires a total of 90 credit hours (up to 30 in dissertation) including 60 hours of study beyond the master’s degree. Required courses in the core are STSS-6200 Science and Social Theory, STSS-6040 Technology and Social Theory, STSS-6100 Policy Seminar, STSS-6120 Advanced Research Methods, and a theory option. STSS-6030 Nature of Inquiry, STSS-6360 Advanced Contemporary Political Thought, and topics courses such as STSS-6961 Structuralism and Post-Structuralism, STSS-6962 Social Theory, and STSS-6963 Feminist and Postcolonial Theory, or other STS graduate courses approved by the graduate committee to meet the theory option. The graduate committee may also approve substitutions of other graduate courses for Advanced Research Methods, either inside or outside the STS Department. Remaining course work is drawn from three areas: policy studies, science studies, and technology studies. At least two additional 6000-level STS seminars (or independent reading courses of three or more students) must be included. The field examination covers two of these three areas.

**Special Graduate Opportunities**

**Certificate in Multidisciplinary Environmental Studies**
This certificate may be awarded to master’s students who choose to add 15 credit hours of science and/or engineering, earning the equivalent of a minor in environmental science or engineering. Courses may include BIOL-4850 Principles of Ecology, CHEM-4810 Chemistry of the Environment, ERTH-4810 Environmental Geology, and IENV-4700 One Mile of the Hudson River, or other environmental courses as approved by the adviser. Students should focus their additional 15 credit hours on an area of study that complements their individual project work in the rest of the program.

**Course Descriptions**
Courses related to all STS curricula are described in the Course Descriptions section of this catalog under the department codes STSH or STSS. Students in these programs often take courses in other Institute departments appropriate to their specific interests.

**Interdisciplinary Programs and Research**
Few institutions better understand that, in an increasingly complex world, individuals often need a broader range of knowledge than can be obtained through study of a single discipline. As a result, the School of Humanities and Social Sciences has developed a strong selection of multidisciplinary academic and research programs. These programs cross not only disciplines, but allow Rensselaer schools to offer the highest possible degree of multidisciplinary education.

In addition to opportunities in the School of Humanities and Social Sciences described below, other interdisciplinary programs available at Rensselaer are listed in the Interdisciplinary Studies Index of this catalog and are described fully in the section pertaining to the associated Institute school or division.
Electronic Media, Arts, and Communication

The Electronic Media, Arts, and Communication (EMAC) program offers undergraduates the opportunity to study electronic arts in relation to the communication field and prepares them for careers in the applied arts and communication. The B.S. degree in EMAC is earned from both the Department of the Arts and the Department of Language, Literature, and Communication (LL&C). It combines offerings in LL&C and ARTS for a total of at least 60 credit hours and consists of courses taken at four levels.

Required introductory courses at Level One are COMM-1510 Introduction to Communication Theory; COMM-2610 Introduction to Visual Communication; ARTS-1020 Media Studio: Imaging; ARTS-1010 Media Studio: Video/Audio. In Level Two, students complete 24 credit hours in selected LL&C and Arts courses in writing (4), art history/theory (4), and a short list of courses in the areas of electronic art; electronic communication and design; literature, film, media and culture; and professional communication. Level Three requires an EMAC concentration, consisting of 12 credit hours of 4000-level LL&C, Arts, or other courses as part of a plan of study approved by the academic adviser. Senior students at Level Four take 8 credits of capstone courses, consisting of 4 credit hours in each of their last two semesters.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IHSS-196x (COMM-1510) Introduction to Communication Theory</td>
<td>4</td>
<td>ARTS-1010 Media Studio: Video/Audio</td>
<td>4</td>
</tr>
<tr>
<td>ARTS-1020 Media Studio: Imaging</td>
<td>4</td>
<td>COMM-2610 Intro. to Visual Communication</td>
<td>4</td>
</tr>
<tr>
<td>Hum.Elective/First-Year Studies</td>
<td>4</td>
<td>CSCI-1100 Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td>MATH-1500 Calculus I for H&amp;SS</td>
<td>4</td>
<td>MATH-1620 Contemp. Math Ideas in Society</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMAC Writing Elective</td>
<td>4</td>
<td>EMAC Art History/Theory</td>
<td>4</td>
</tr>
<tr>
<td>EMAC Art Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Social Science Elective</td>
<td>4</td>
<td>EMAC Language, Literature and Comm. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Elective</td>
<td>4</td>
<td>Humanities Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMAC Art Elective</td>
<td>4</td>
<td>EMAC Concentration</td>
<td>4</td>
</tr>
<tr>
<td>EMAC Language, Literature, and Comm. Elective</td>
<td>4</td>
<td>Humanities Elective</td>
<td>4</td>
</tr>
<tr>
<td>Social Science Elective</td>
<td>4</td>
<td>Hum./Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Math/Science Elective</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
</tbody>
</table>
### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMAC Concentration</td>
<td>4</td>
<td>EMAC Concentration</td>
<td>4</td>
</tr>
<tr>
<td>Capstone Course</td>
<td>4</td>
<td>Free Elective</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td>Capstone Course</td>
<td>4</td>
</tr>
<tr>
<td>Free Elective</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 EMAC Writing Electives (4 credit hours required) WRIT-1110; WRIT-2110.

2 Art History/Theory Electives (4 credit hours required) ARTS-2100; ARTS-2500; ARTS-2540; ARTS-2510; ARTS-296x (approved Topics in Art History/Theory); ARTS-4100; ARTS-4120.

3 EMAC Computer Arts Electives (8 credit hours required) ARTS-2010; ARTS-2020; ARTS-2030; ARTS-2040.

4 EMAC Language, Literature, and Communication Electives (8 credit hours required) Students must select courses from two separate areas of EMAC LL&C Electives. These areas are: Electronic Communication and Design, Literature, Film, Media and Culture, and Professional Communication. Electronic Communication and Design: COMM-296x (approved Topics courses); COMM-4340; COMM-4650; COMM-4690; COMM-4750; COMM-4720; WRIT-2510.

Literature, Film, Media, and Culture: COMM-2410; COMM-2460; COMM-296x; COMM-4580; Any literature course (LITR 2000-4000); LITR-2420; LITR-2460; LITR-4410; LITR-4450.

Professional Communication: WRIT-2340; WRIT-2360; WRIT-2410; WRIT-2500; WRIT-2520; WRIT-296x. (approved Topics in Profess. Comm.)

5 EMAC Concentration (12 credit hours at 4000 level required) A thematic concentration is required of all EMAC majors. ARTS, LL&C, or any thematically related courses in other departments may be taken with approval of the academic adviser. This concentration will provide depth and may lead toward (or be taken in conjunction with) the EMAC Capstone Courses.
Ecological Economics, Values, and Policy

Director: Steven Breyman, Science and Technology Studies

The Departments of Science and Technology Studies and Economics jointly offer the Program in Ecological Economics, Values, and Policy (EEVP), which offers both bachelor’s and master’s of science degrees. EEVP combines the best of both departments—economic analysis and a broader humanities and social science analysis that emphasize the roles science and technology play in today's global economy and culture. Given the strong interdisciplinary background acquired in EEVP, graduates can play leading roles in resolving the critical environmental and social problems of the 21st century. The United Nations reports that the demand for EEVP-type program graduates exceeds the supply. According to the UN, it is crucial that we educate people who understand that “sustainable development does not merely deal with the conservation of nature or the management of ecosystems, but more broadly and fundamentally aims at new models of societal development and social transformation.”

Baccalaureate Program

EEVP has four main components: eight economics courses (all courses are 4 credit hours), eight STS courses, 10 science or engineering courses, and four free electives as well as an H&SS First-Year Studies course. The science and engineering component should earn the equivalent of a minor in environmental science or engineering, which can cover such topics as ecology, environmental chemistry or geology, water and wastewater infrastructure, and hazardous waste management. In addition, the economics and social science courses that form the core of EEVP equip students with a variety of skills and methods to assess the economic costs, human health impacts, and quality-of-life changes that are associated with the evolving lifestyles and living conditions in today’s society. Cultural studies add to EEVP’s strong global focus, which prepares students for a successful career in policy analysis, international development, project assessment, and many other areas. The capstone STS Senior Project, on which students work with an adviser from each department, integrates the economics and STS components.

To illustrate a typical distribution of these courses over the regular four-year period of bachelor’s degree study, a sample semester layout is provided below.

### First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>MATH-1500</td>
<td>Calculus I for H&amp;SS</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STSH-1110</td>
<td>Science, Technology &amp; Society</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ECON-1200</td>
<td>Introductory Economics</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>MATH-1520</td>
<td>Mathematical Methods in Mgmt. and Econ</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Science Sequence II</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STSS-2300</td>
<td>Environment &amp; Society</td>
<td>4</td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>ECON-2010</td>
<td>Managerial Economics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>STS Concentration Option</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>ECON-2020</td>
<td>Intermed. Macro. Econ</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Free Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STS Methods/Stats. Opt</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>
Concentrations

The EEVP curriculum offers several concentration “options” each of which is described below.

STS Concentration option In addition to taking STSS-2300 Environment and Society in the fall of the second year, students choose one other STS concentration course: STSS-2100 Medicine and Society; STSS-2400 Law, Values, and Public Policy; STSS-2500 Historical and Cultural Perspectives on Science and Technology; or STSS-2200 Engineering, Design, and Society.

STS Methods/Statistics option Students choose one course in either research methods, such as STSS-4130 Decision Making; or statistical methods, such as PSYC-2310 Experimental Methods and Statistics or DSES-4140 Statistical Analysis.

STS Technical option Students choose four courses, together with the Institute Science core requirement of six courses, to earn the equivalent of a minor in environmental science or engineering. This option includes such courses as BIOL-4850 Principles of Ecology, CHEM-4810 Chemistry of the Environment, and ERTH-1200 Geology II (surface geology) or ENVE courses as approved by the adviser.

Advanced STS option Students choose two courses from the following list:

- ECON-4210 Cost Benefit-Analysis
- ECON-4230 Environmental Economics
- ECON-4240 Natural Resource Economics, and
- ECON-4250 Ecological Economics
- STSH-4300 Environmental Philosophy
- STSS-4320 Environmental Politics and Policy
- STSS-4390 Environment and International Policy
- STSS-4400 Risky Technologies
- STSS-4500 Environment and Development
- STSS-4540 Environment, Law, and Culture
- STSS-4920 Topics in STS (e.g., Environment and Health)
Master’s Program
The Departments of Science and Technology Studies and Economics also jointly offer an EEVP master’s program. The program builds on Rensselaer’s nationally recognized expertise and course offerings in the economic, political, social, cultural, and ethical implications in the interactions of science, technology, environment, and society. EEVP is meant for early and mid-career professionals in state and local government, secondary education, business, and the nonprofit sector (professionals in environmental nongovernmental organizations) who wish to upgrade their skills and advance their careers.

Building on required courses in environmental, ecological, and natural resource economics and in environmental philosophy and policy, EEVP helps students acquire the skills such as policy analysis and ecological valuation that are necessary to address the complex multidisciplinary problems any society faces in areas such as environment and health, appropriate technology, and sustainable development. The 21st century promises a continuation of the march toward globalization. Dealing with the prospects and problems of a world economy and the growing human impact on the natural world requires an education that is both broad and deep. EEVP offers “hands on” training that puts into practice the slogan “think globally, act locally.”

Economics requirements for the EEVP master’s degree include two common courses for a total of 6 credit hours—ECON/STSS-6600 Seminar in EEVP (the common introductory course) and ECON/STSS-6650 EEVP Professional Project (the common capstone course). Also required are four economics courses for a minimum of 12 credit hours.

Additional requirements include ECON-6490 Introduction to Economic Theory, and two of the following three courses:

ECON-6230 Advanced Environmental Economics
ECON-6240 Advanced Natural Resource Economics
ECON-6250 Advanced Ecological Economics

Sample electives are ECON-4150 Economics of Government Regulation, ECON-4160 Public Finance, ECON-4190 International Economics, ECON-6210 Advanced Cost Benefit Analysis, ECON-6550 Advanced Microeconomic Analysis, and ECON-6590 Advanced Macroeconomic Analysis. In addition, students must take 4 STS course electives for a minimum of 12 credit hours.

STS course requirements for the EEVP masters include STSH-6300 Environmental Philosophy, STSS-6300 Environment and Social Theory, and one of the following two courses:

STSS-6320 Environmental Politics and Policy
STSS-6540 Environment, Law, and Culture


All together, the program totals 10 courses for a minimum of 30 credit hours and can be completed with all 6000-level courses at 3 credit hours. However, if students choose to take one or two 4000-level electives at 4 credit hours, they will earn either 31 or 32 credit hours.

These courses are offered in a pattern that allows students to complete the program while holding everyday jobs. Courses are offered at night, in a series of intensive weekends, or in the summer in an alternating fashion making it possible to take the 10 required courses in two years.
Environmental Studies Program

Co-directors: Nicholas L. Clesceri, Environmental Engineering
Carl N. McDaniel, Environmental Science
Steven Breyman, Science and Technology Studies

From local controversies of waste treatment to international negotiations on global warming, the environment has become one of the most important current and future issues. To face the challenges of environmental problems, students need more than the specialized knowledge of a single discipline. Building on the unusual strength and breadth of Rensselaer’s synthesis of engineering, science, and the humanities and social sciences, the Environmental Studies Program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies.

Students entering Rensselaer in the Environmental Studies Program take a broad range of basic courses in their first two years and then choose one of five majors: economics (with an ecological economics focus); environmental engineering; environmental science (with a concentration in a specific area of science); hydrogeology; or science, technology, and society (with an environmental focus). Graduates of the Environmental Studies Program will not be narrow specialists; they will receive the kind of multidisciplinary education that is required to address complex environmental problems.

Baccalaureate Program

In the first and second years, students are encouraged to select an introductory program from the following basic courses. An adviser chosen from among the co-directors listed above guides the student in selecting and ordering courses.

Science
Biology
BIOL-1010 Introduction to Biology
BIOL-1020 Introduction to Biology Laboratory
BIOL-2310 Microbiology
BIOL-4850 Principles of Ecology

Chemistry
CHEM-1100 Chemistry I
CHEM-1200 Chemistry II
CHEM-2250 Organic Chemistry I
CHEM-2230 Organic Chemistry Laboratory I
CHEM-4810 Chemistry of the Environment

Earth and Environmental Sciences
ERTH-1200 Geology II: Earth's Surface
ERTH-4180 Environmental Geology

Mathematics and Computer Science
MATH-1010 Calculus I
MATH-1020 Calculus II
CSCI-1100 Computer Science I

Physics
PHYS-1100 Physics I
PHYS-1200 Physics II
Engineering
Environmental and Energy Engineering
ENVE-2110 Introduction to Environmental Engineering

Humanities and Social Sciences
Economics
ECON-1200 Introductory Economics
ECON-4230 Environmental Economics

Interdisciplinary
IHSS-2100 Introduction to Environmental Studies

Science and Technology Studies
STSS-1100 Introduction to Science and Technology Studies
STSS-2300 Environment and Society
For an engineering emphasis and to be prepared to take certain courses in an environmental engineering minor, students should try to include the following courses in their basic courses in the first and second years:
MATH-2400 Introduction to Differential Equations
ENGR-1500 Chemistry of Materials I
ENGR-1600 Chemistry of Materials II (instead of CHEM-1100, CHEM-1200)
ENGR-1100 Introduction to Engineering Analysis
ENGR-2250 Thermal and Fluids Engineering I

Dual Major Programs
Environmental Studies Program students may choose a dual major program, Ecological Economics, Values, and Policy, which includes economics and science, technology, and society.

Minor Programs
To complete their degrees, students may earn a wide variety of minors. All majors in the program offer their own environmental studies minors, and the Schools of Architecture and Management offer special environmental courses as well.

In addition to the basic courses in the first and second years, courses for a minor may be selected from among the following courses, but students should consult the appropriate sections of this catalog for the specific details of each major and minor included in the Environmental Studies Program, especially to determine the prerequisites for taking the listed courses.

Science
Biology
BIOL-2160 Introductory Biotechnology
BIOL-4310 Industrial Microbiology
BIOL-4320 Geomicrobiology
BIOL-4440 Microbial Biology
BIOL-4700 Freshwater Ecology
BIOL-4870 Environmental Toxicology

Chemistry
CHEM-2260 Organic Chemistry II
CHEM-2240 Organic Chemistry Laboratory II
CHEM-4530 Modern Techniques in Chemistry
CHEM-4450 Macroscopic Physical Chemistry
CHEM-4460 Microscopic Physical Chemistry

* A special topics course.
**Earth and Environmental Sciences**
- ERTH-1100 Geology I: Earth's Interior
- ERTH-4190 Environmental Measurement
- ERTH-4400 Energy and Mineral Resources
- ERTH-4680 Applied Geophysics
- ERTH-4710 Groundwater Hydrology
- ERTH-4740 Applied Groundwater Modeling

**Engineering**

**Environmental and Energy Engineering**
- ENVE-4310 Applied Hydrology and Hydraulics
- ENVE-4320 Environmental Chemodynamics
- ENVE-4330 Atmospheric Pollution
- ENVE-4340 Physicochemical Processes in Environmental Engineering
- ENVE-4350 Biological Processes in Environmental Engineering
- ENVE-4170 Environmental Process Design I
- ENVE-4180 Environmental Process Design II
- ENVE-4200 Solid and Hazardous Waste Engineering
- ENVE-4210 Industrial Waste Treatment and Disposal
- ENVE-4960 Bioremediation of Toxic and Hazardous Wastes*

**Humanities and Social Sciences**

**Economics**
- ECON-4210 Cost-Benefit Analysis
- ECON-4240 Natural Resource Economics
- ECON-4250 Ecological Economics

**Science and Technology Studies**
- STSH-4300 Environmental Philosophy
- STSS-2400 Law, Values, Public Policy
- STSS-4320 Environmental Politics and Policy
- STSS-4330 World Politics
- STSS-4390 Environment and International Policy
- STSS-4400 Risky Technologies
- STSS-4500 Environment and Development
- STSS-4540 Environment, Law, and Culture

**Interschool Minor in Energy**

**Co-directors:** Michael K. Jensen, Mechanical Engineering
David J. Hess, Science and Technology Studies

Any thoughtful discussion of the challenges faced in the 21st century will refer to energy. Rensselaer is uniquely able to offer students in any undergraduate major an opportunity to learn about the wide variety of issues involved in understanding energy. The interschool minor in energy includes fundamental courses in architecture, engineering, management, science, and the humanities and social sciences. Any student wishing to develop a multidisciplinary background in energy should consider this minor.

The minor requires a minimum of four courses. Three of these courses, ENGR-1200 Engineering Graphics and CAD, MANE-4960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics, and ERTH-4400 Energy and Mineral Resources, are required.

If any of the above courses are also required for a student’s major, the student should substitute an additional course from Option Two below. At least one more course much also be taken from Option One.

**Option One**

<table>
<thead>
<tr>
<th>Course</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON-4240 Natural Resource Economics</td>
<td>STSS-4390 Environmental and International Policy</td>
</tr>
<tr>
<td>STSH-4300 Environmental Philosophy</td>
<td>STSS-4400 Risky Technologies</td>
</tr>
<tr>
<td>STSS-2300 Environment and Society</td>
<td>STSS-4500 Environment and Development</td>
</tr>
<tr>
<td>STSS-4320 Environmental Politics and Policy</td>
<td>STSS-4540 Environment, Law, and Culture</td>
</tr>
<tr>
<td>STSS-4300 World Politics</td>
<td></td>
</tr>
</tbody>
</table>

* This is a special topics course.
Minds and Machines Program

**Director:** Bram van Heuveln, Cognitive Science

The Minds and Machines (M&M) Program offers students a number of options for the B.S. degree in combination with hands-on research that starts at the beginning of the first year, in connection with the Rensselaer AI and Reasoning Laboratory (RAIR Lab). This course work and research prepares students to build and manage the building of both “smart” machines (e.g., intelligent agents that search the Web, expert systems, robots) and machines enhance human intelligence (e.g., better human-machine interfaces, Web browsers that learn from our surfing, automated theorem-provers). Learning by doing is emphasized and the doing, even for students new to the program, involves hands-on research at the intersection of computer science, logic, psychology, artificial intelligence, and relevant areas of engineering (e.g., computer systems, electrical, mechanical). Research is carried out in the Department’s various labs and includes projects described on the program’s Web site. Much of the undergraduate research in the M&M Curriculum and RAIR Laboratory reflects an entrepreneurial spirit. For example, students working in the gaming area are encouraged to try to build systems that can be sold in the marketplace.

**Baccalaureate Program**

M&M students select a bachelor of science “trajectory” that matches their interests and the part of the information economy in which they wish to work or the area of graduate study they may wish to pursue. Trajectories include B.S. degrees in:

- **Computer Science and Psychology Information Technology and Psychology**—appropriate for students interested in gaming technology and gaming industry.
- **Information Technology and Pre-Law**
- **Computer Systems Engineering (or Electrical Engineering or Mechanical Engineering) and Psychology**—appropriate for students interested in robotics.
- **Computer Science and Philosophy**—especially appropriate for students interested in logic-based systems, e.g., expert systems
- **Psychology**—includes courses having a computational emphasis.

In addition to developing technical expertise in the relevant areas of information technology, the Minds and Machines dual majors allow students to analyze and discuss (with the help of science fiction films) the “big” questions that research and engineering in the program raise. These include questions such as: How smart can machines get? Can they become as smart as human? Is creativity the line that machines will never cross? Can machines be conscious, and how can humans tell?

For further information, access the program’s Web site through the home page of chair, Selmer Bringsjord, at [www.rpi.edu/~brings](http://www.rpi.edu/~brings) or contact him directly at selmer@rpi.edu.

**Typical Four-Year Sequence for Computer Science-Philosophy Dual Major**

**Freshman Year**

<table>
<thead>
<tr>
<th>Fall Semester</th>
<th>Spring Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Science I......................................</td>
<td>Computer Science II..................................</td>
</tr>
<tr>
<td>Calculus I...............................................</td>
<td>Calculus II..........................................</td>
</tr>
<tr>
<td>Introduction to Philosophy................................</td>
<td>Intro to Discrete Structures........................</td>
</tr>
<tr>
<td>Minds &amp; Machines*.......................................</td>
<td>Philosophy Elective..................................</td>
</tr>
</tbody>
</table>

* A special Topics Course
**Sophomoren Year**

**Fall Semester**
- Data Structures & Algorithms ................................................. 4
- Computer Organization ....................................................... 4
- Introduction to Logic* ......................................................... 4
- H&SS Elective .................................................................... 4

**Spring Semester**
- Models of Computation ......................................................... 4
- Math Elective ..................................................................... 4
- Introduction to Cognitive Science* ...................................... 4
- Philosophy Elective .............................................................. 4

**Junior Year**

**Fall Semester**
- Programming Languages ..................................................... 4
- Philosophy Elective .............................................................. 4
- Science Elective ................................................................. 4
- Artificial Intelligence* .......................................................... 4

**Spring Semester**
- Operating Systems ............................................................... 4
- Philosophy Elective .............................................................. 4
- Science Elective ................................................................. 4
- H&SS Elective .................................................................... 4

**Senior Year**

**Fall Semester**
- Senior Thesis ................................................................. 4
- Software D&D .................................................................... 4
- H&SS Elective ................................................................. 4
- Free Elective ..................................................................... 4

**Spring Semester**
- Senior Thesis ................................................................. 4
- Somp Sci Elective .............................................................. 4
- H&SS Elective ................................................................. 4
- Free Elective ..................................................................... 4

**Sample Four-Year Sequence for Computer Science-Psychology Dual Major**

**Freshman Year**

**Fall Semester**
- Computer Science I ............................................................. 4
- Calculus I ......................................................................... 4
- General Psychology ............................................................ 4
- Minds & Machines* .............................................................. 4

**Spring Semester**
- Computer Science II ............................................................ 4
- Calculus II ......................................................................... 4
- Experimental Methods & Statistics ................................... 4
- Intro to Discrete Structures ................................................. 4

**Sophomore Year**

**Fall Semester**
- Data Structures & Algorithms ................................................. 4
- Computer Organization ....................................................... 4
- Psychology Elective ............................................................. 4
- Introduction to Logic* ......................................................... 4

**Spring Semester**
- Models of Computation ......................................................... 4
- Math Elective ..................................................................... 4
- Introduction to Cognitive Science* ...................................... 4
- H&SS Elective .................................................................... 4

**Junior Year**

**Fall Semester**
- Programming Languages ..................................................... 4
- Psychology Elective ............................................................. 4
- Science Elective ................................................................. 4
- Artificial Intelligence* .......................................................... 4

**Spring Semester**
- Operating Systems ............................................................... 4
- Psychology Elective .............................................................. 4
- Science Elective ................................................................. 4
- H&SS Elective .................................................................... 4

* Recommended
Senior Year

Fall Semester
Senior Thesis ................................................. 4
Software D&D ................................................. 4
H&SS Elective .................................................. 4
Free Elective .................................................... 4

Spring Semester
Senior Thesis ................................................. 4
Comp Sci Elective ............................................. 4
H&SS Elective .................................................. 4
Free Elective .................................................... 4

Product Design and Innovation

Director: Jeff Hannigan, Science and Technology Studies

The Schools of Engineering, Architecture, Science, and Humanities and Social Sciences jointly offer this dual major program called Product Design and Innovation (PDI). The program offers three tracks: the first satisfies the requirements for the B.S. programs in both Mechanical Engineering and Science, Technology, and Society (STS); the second satisfies the requirements for the B.S. programs in both Information Technology and STS; and the third satisfies the requirements for the B.S. program in both Building Sciences and STS.

PDI prepares students to become innovative designers capable of developing and designing the advanced products and technologies for the 21st century. Built around a design studio every semester, PDI combines the technical, aesthetic, and cultural sophistication of Rensselaer’s engineering, information technology, or building science curricula with the insight and vision of the humanities and social sciences disciplines in the STS curriculum.

Through the PDI core of design studios taken every semester, students obtain a hands-on opportunity that brings together the major curricula. The accredited mechanical engineering curriculum provides a fundamental education in mechanical engineering with a focus on design methodology in general and mechanical design techniques in particular (see template below). The information technology curriculum provides a foundation for applying information technology to other disciplines, including high technology product design. The distinction between product design and software design is that in addition to learning how to design technical aspects of the product, students will create work that is a bridge between both digital and physical form (see template below). The building science curriculum provides a fundamental education in building science and architectural design through basic and advanced courses in structures, environmental, and construction systems, as well as physical and theoretical approaches in design (see template below). The STS curriculum provides a fundamental education in the historical, ethical, cultural, and policy dimensions of product development and innovation, including numerous case studies of successes and failures through which students learn what it takes to be effective leaders of design teams. On this basis, the design studies help students explore and develop their creativity while building a portfolio of design experiences continuously throughout all four years.

The design experiences range over a breadth of problems, from larger systemic problems to smaller focused problems, so that students have broad exposure to all the different applications of design practice. Some fall and spring semester studios are taught as a sequence to give students experience with the design process from beginning to implementation. The studios also develop students’ skills in using computers and other advanced tools and techniques, as well as in drawing, visualizing, communicating, and working together. In short, the program’s design aspects provide the elements necessary to put students’ creativity to work as leaders of design and innovation, whether it is in a multinational business at the cutting edge of the global market or in a smaller business that creates an unusual solution to a local problem.
## PDI Curriculum in Mechanical Engineering and STS

### First Year

#### Fall
- **ARCH-xxxx** Design Studio I ........................................4  
- **STSH-1110** Introduction to STS (First-Year Studies) ..............4  
- **MATH-1010** Calculus I ........................................4  
- **ENGR-1500** Chemistry of Materials I ............................4  
- **ENGR-1200** Engineering Graphics and CAD 1 ........................1  

### Spring
- **ENGR-1960** Design Studio II 2 .....................................4  
- **ENGR-1100** Introduction to Eng. Analysis ..........................4  
- **MATH-1020** Calculus II ........................................4  
- **STSH-2960** Design, Culture, and Society ..........................4  
- **ENGR-1300** Engineering Processes 1 ..............................1  

### Second Year

#### Fall
- **IHSS-2500** Design Studio III 3 .....................................4  
- **ENGR-1600** Chemistry of Materials II .............................4  
- **MATH-2400** Intro. to Differential Equations ........................4  
- **PHYS-1100** Physics I for Engineers .................................4  
- **CSCI-1190** Programming ........................................4  

#### Spring
- **ENGR-2050** Introduction to Eng. Design with Prof. Dev. ............4  
- **ENGR-2530** Strength of Materials ..................................4  
- **ENGR-2090** Engineering Dynamics ................................4  
- **PHYS-1200** Physics II for Engineers ...............................4  

### Third Year

#### Fall
- **STSH-4960** Design Studio V (Industrial Design) ........................4  
- **ENGR-2350** Embedded Control .....................................4  
- **ENGR-2710** General Manufacturing Processes .........................4  
- **ENGR-2600** Modeling and Analysis of Uncertainty ..................4  
- **STSS-4xxx** STS Advanced Option 4 .................................4  

#### Spring
- **ENGR-4960** Design Studio VI .............................4  
- **ENGR-4050** Modeling and Control .................................4  
- **STSS-4xxx** STS Advanced Option 4 .................................4  
- **ENGR-2250** Thermos/Fluids Engineering I ..........................4  

### Fourth Year*

#### Credit hours
- **ENGR-4960** Design Studio VII 1 .......................................4  
- **STSS-4800** Public Service Internship 6 .............................4  
- **ENGR-4300** Electronic Instrumentation ................................4  
- **MEAE-4030** Elements of Mechanical Design ........................4  
- **ENGR-4960** Capstone Design Studio with Prof. Develop. III 1 ........................................4  

#### Credit hours
- **STSS-4980** STS Senior Project 7 .................................4  
- **MANE-4020** Thermal and Fluids Engineering II ..................4  
- **MANE-4040** Mechanical Systems Lab ...............................2  
- **MANE-4020** Thermal and Fluids Lab ...............................2  

*See adviser for fall/spring order of fourth-year courses.

1 These courses may be taken in any order.

2 PDI II, V, VI, and VII satisfy the mechanical engineering requirement for the concentration elective.

3 For PDI students, Design Studio III can be substituted for one of the two STS concentration options.

4 Candidate courses include: STSS-4350; STSS-4960; STSS-4960; STSH-4230; STSS-4110; STSS-4250; STSS-4310; STSS-4560; and STSS-4650.

5 It is recommended that the sequence of Design Studio VII and VIII be taken as Multidisciplinary Design Lab 1 and 2.

6 This course satisfies the requirement for Professional Development II.

7 The STS Senior Project can be combined with the Capstone Design Studio to make an eight-credit capstone studio project.
## PDI Curriculum in Information Technology and STS

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-1210</td>
<td>IT Revolution 2</td>
<td>ITEC-1220</td>
<td>Politics &amp; Economics of IT 2</td>
</tr>
<tr>
<td>STSH-1110</td>
<td>Science, Technology, &amp; Society 1</td>
<td>MATH-1010</td>
<td>Calculus 1 1</td>
</tr>
<tr>
<td>(First-Year Studies)</td>
<td></td>
<td>CSCE-1200</td>
<td>Comp Science 2 1</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science 1 3</td>
<td>ENGR-1300</td>
<td>Design Studio II</td>
</tr>
<tr>
<td>ARCH-196</td>
<td>Design Studio I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-2500</td>
<td>Computer Organization 1</td>
<td>CSCI-2300</td>
<td>Data Structures and Algorithms 1</td>
</tr>
<tr>
<td>ITEC-2210</td>
<td>Intro to HCI 1</td>
<td>STSS-2500</td>
<td>Information, Society, and Culture 1</td>
</tr>
<tr>
<td>ITEC-2110</td>
<td>Exploiting the Info. World 1</td>
<td>STSH-2960</td>
<td>Design, Culture, and Society 1</td>
</tr>
<tr>
<td>IHSS-2500</td>
<td>Design Studio III 5</td>
<td></td>
<td>Math Core 2 1</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-4310</td>
<td>Managing IT Resources 1</td>
<td>IITEC-4960</td>
<td>Design Studio VI: Creative Design in IT</td>
</tr>
<tr>
<td></td>
<td>Science Core Elective 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Probability &amp; Statistics Elective 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>STS Methods Option 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ARCH-4960</td>
<td>Design Studio V: Industrial Design 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STSH-4960</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STSS-4800</td>
<td>Public Service Internship 1</td>
<td>STSS-4980</td>
<td>STS Senior Project 1</td>
</tr>
<tr>
<td>STSS Advanced Option 1</td>
<td></td>
<td></td>
<td>HSS Core Elective 1</td>
</tr>
<tr>
<td>HSS Core Elective 1</td>
<td></td>
<td></td>
<td>HSS Core Elective 1</td>
</tr>
<tr>
<td>IITEC-4100</td>
<td>Design Studio VII: IT Capstone Studio 1</td>
<td>STSS-4960</td>
<td>Design Studio VIII: PDI Capstone 1</td>
</tr>
</tbody>
</table>

1 The total number of credits is 132.

2 Fulfills the requirements for the H&SS core.

3 Fulfills the requirements for the science core.

4 Fulfills the IT core requirements. For the Probability & Statistics Elective (fall third year) and the IT Technology Elective (spring third year), see the IT requirements in the Information Technology section of the catalog.

5 Fulfills the requirements for the second discipline in IT and the STS major core. For the STS Advanced Option (a 4000-level STS course), it is recommended that students select a course in either the “Engineering, Design, and Society” track or the “Information, Society, and Culture” track. See the STS section of the catalog for details on this and other STS course requirements. For PDI students, Design Studio III can be substituted for one of the two STS concentration options.
PDI Curriculum in Building Science and STS

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-2210 Architectural Design I</td>
<td>4</td>
<td>ARCH-2220 Architectural Design II</td>
<td>6</td>
</tr>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>STSH-1110 Introduction to STS</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-2110 Building and Thinking of Arch. I</td>
<td>4</td>
<td>PHYS-1050 Physical Principles of Design</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-2200 Design Studio</td>
<td>4</td>
<td>ARCH-2120 Building and Thinking of Arch. II</td>
<td>2</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHSS-2500 Design Studio III</td>
<td>4</td>
<td>ENGR-2050 Introduction to Eng. Design</td>
<td>4</td>
</tr>
<tr>
<td>STSS-2200 Engineering, Design, and Society</td>
<td>4</td>
<td>ARCH-2340 Environmental Systems</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-2310 Contemporary Design Approaches</td>
<td>2</td>
<td>Science Sequence II</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-2120 Contemporary Design Approaches</td>
<td>2</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4960 Design Studio V (Industrial Design)</td>
<td>4</td>
<td>ARCH-4960 Design Studio VI</td>
<td>4</td>
</tr>
<tr>
<td>STSS-4800 Public Service Internship</td>
<td>4</td>
<td>STSS-4xxx STS Advanced Option</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-4700 Advanced Structures and Construction Systems</td>
<td>4</td>
<td>ARCH-4750 Advanced Environmental Systems</td>
<td>4</td>
</tr>
<tr>
<td>DSES-2010 Statistics</td>
<td>4</td>
<td>ARCH-xxxx Concentration Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARCH-4960 Design Studio VII</td>
<td>4</td>
<td>ARCH-4960 Design Studio VII</td>
<td>4</td>
</tr>
<tr>
<td>STSS-4xxx STS Advanced Option</td>
<td>4</td>
<td>STSS-4980 STS Senior Project</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-xxxx Final Project</td>
<td>2</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>ARCH-4510 Construction Industry Seminar</td>
<td>2</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

1 For PDI students, Design Studio III can be substituted for one of the two STS concentration options.

2 The science sequence may be selected, with the assistance of the student’s adviser, from among 1000-level introductory sequences in Biology, Chemistry, Geology, or Physics, including ERTH-1030, ERTH-1040.

3 Candidate courses include: STSS-4350; STSS-4960; STSS-4960; STSH-4230; STSS-4110; STSS-4250; STSS-4310; STSS-4560; and STSS-4650.

4 The STS Senior Project can be combined with the Capstone Design Studio to make an 8-credit capstone studio project.
Table of Contents

Undergraduate Programs  297
Graduate Program       301
Recognizing that Information Technology (IT) is the “enabler of the Information Age,” Rensselaer has made IT one of its top academic priorities. The Institute has developed a highly interdisciplinary program that emphasizes IT’s application to nearly every field from science and engineering to management to humanities and social sciences. The IT degree programs are designed for students with a strong technical aptitude that they wish to apply to other interests.

Rensselaer’s undergraduate and graduate IT degree programs consist of two components. The first is a set of core courses, many of which are technical in nature. The second is the concentration area in which students are expected to employ their technical expertise.

Each of Rensselaer’s five schools offers concentration area options to IT students, and a greater percentage of Rensselaer’s distinguished faculty is involved in IT than in any other campus department or program. The curriculum committees of each of the five schools supported and formulated the IT degrees. Many Rensselaer faculty members representing a wide variety of the disciplines taught at the Institute contribute to this program, thereby providing students with a broad range of perspectives on IT and the breadth of its impact on the world.

Information technology degrees available at Rensselaer include the Bachelor of Science and the Master of Science. Opportunities for Ph.D. level work in IT are under development. Those holding these degrees are in great demand and command some of the highest starting salaries and bonuses in any profession.

**Faculty**

**Professors**

**Bailey, R.A.**—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts (Science).

**Breneman, C.M.**—Ph.D. (University of California, Santa Barbara); physical organic chemistry (Science).

**Bringsjord, S.**—Ph.D. (Brown University); logic, philosophical logic, philosophy of artificial intelligence (Humanities and Social Sciences).

**Connor, K.**—Ph.D. (Polytechnic Institute of New York); electromagnetic theory, wave propagation, plasmas for fusion research and industrial applications, finite element methods (Engineering).

**Flaherty, J.E.**—Ph.D. (Polytechnic Institute of Brooklyn); numerical analysis, scientific computation, parallel computation, adaptive methods (Science).

**Gabriele, G.A.**—Ph.D. (Purdue University); design automation, design optimization (Engineering).

**Gerhardt, L.A.**—Ph.D. (State University of New York, Buffalo); communication systems, digital voice and image processing, adaptive systems and pattern recognition, integrated manufacturing (Engineering).
Goldberg, M.K.—Ph.D. (Institute of Mathematics, Novosibirsk, Russia); algorithms for combinatorial optimization, experimental algorithm design and analysis, computational learning theory, graph theory (Science).

Gowdy, J.M.—Ph.D. (West Virginia University); ecological economics, industrial organization and public regulation, regional economics (Humanities and Social Sciences).

Haddock, J.—Ph.D. (Purdue University); modeling of production and service systems including simulation and optimization techniques (Management).

Herron, I.—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability (Science).

Hess, D.—Ph.D. (Cornell University); science, culture, and power; social studies of alternative medicine (Humanities and Social Sciences).

Hsu, C.—Ph.D. (Ohio State University); metadatabase and information systems, Internet enterprises planning, database and knowledge-based systems, computerized manufacturing, enterprise integration and modeling, information visualization, economic evaluation of cyberspace-augmented enterprises (Engineering).

Isaacson, D.—Ph.D. (New York University); mathematical physics, biomedical applications (Science).

Kagan, L.—M.A. (University at Albany, SUNY); studio arts (Humanities and Social Sciences).

Kapila, A.—Ph.D. (Cornell University); applied mathematics, combustion, fluid mechanics (Science).

Lahey, R.T., Jr.—Ph.D. (Stanford University); multiphase flow and boiling heat transfer, reactor safety analysis, reactor thermal-hydraulics, and applications of chaos theory (Engineering).

List, G.F.—P.E., Ph.D. (University of Pennsylvania); intelligent transportation systems, sensors, instrumentation and control, multiobjective stochastic routing and siting, freight network planning (Engineering).

Malmborg, C.J.—Ph.D. (Georgia Institute of Technology); modeling and analysis of problems in facility design, materials handling, materials flow, storage systems, simulation-based optimization methods, manufacturing systems, decision analysis (Engineering).

McLaughlin, H.W., II—Ph.D. (University of Maryland); applied geometry (Science).

Musser, D.—Ph.D. (University of Wisconsin); programming methodology, generic software libraries, formal methods of specification and verification, automated theorem proving (Science).

Napolitano, J.—Ph.D. (Stanford University); experimental nuclear and particle physics (Science).

Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology; subsurface microbiology (Science).

Rajan, K.—Sc.D. (Massachusetts Institute of Technology); electron microscopy, electronic materials, thin films and super lattices (Engineering).

Roberge, W.G.—Ph.D. (Harvard University); theoretical astrophysics (Science).

Salerno, J.C.—Ph.D. (University of Pennsylvania); bioenergetics, spectroscopy, metalloproteins (Science).

Siegmann, W.L.—Ph.D. (Massachusetts Institute of Technology); applied mathematics, wave propagation (Science).

Spooner, D.L.—Ph.D. (Pennsylvania State University); database systems, database security, and database browsing and visualization (Science).

Wait, S.C., Jr.—Ph.D. (Rensselaer Polytechnic Institute); spectroscopy, vibrational and electronic spectroscopy (Science).

Warden, J.T.—Ph.D. (University of Minnesota); ESR spectroscopy, photosynthetic electron transport mechanisms (Science).

Willemain, T.—Ph.D. (Massachusetts Institute of Technology); probabilistic modeling, data analysis, forecasting (Engineering).
Clinical Professors
Danchak, M.M.—Ph.D. (Rensselaer Polytechnic Institute); human computer interaction, usability, information visualization, techniques for distance learning and human learning models (Science).
DeNoia, L.—Ph.D. (Brown University); telecommunications, networking, network management, effective IT organizations (Rensselaer at Hartford).
Hughes, G.—Ph.D. (Princeton University); global economics, economics of information technology (Management).
McKim, J.—Ph.D. (University of Iowa); computer and information sciences (Rensselaer at Hartford).

Associate Professors
Adali, S.—Ph.D. (University of Maryland); heterogenous distributed information systems, database systems (Science).
Breyman, S.—Ph.D. (University of California, Santa Barbara); political economy of environment, science, and society (Humanities and Social Sciences).
Embrechts, M.J.—Ph.D. (Virginia Polytechnic Institute); fusion engineering, applied chaos theory, neural networks (Engineering).
Fortun, K.—Ph.D. (Rice University); international politics, environmentalism and the law (Humanities and Social Sciences).
Hanna, M.H.—Ph.D. (University of Illinois); slime mold development and genetics (Science).
Hannigan, J.—M.Arch. (Pratt Institute); product design, sustainable systems, history of communication (Humanities and Social Science).
Kalsher, M.J.—Ph.D. (Virginia Polytechnic Institute and State University); human factors, industrial/organizational psychology, applied experimental psychology (Humanities and Social Sciences).
Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming languages, analysis of algorithms (Science).
Krueger, T.—M.Arch. (Columbia University); human-environment interaction, design (Architecture).
Leifer, R.—Ph.D. (University of Wisconsin); organizational behavior and organizational design, management information systems (Management).
Massie, W.—M.Arch (Columbia University); architectural design, advanced computer applications and emerging technologies, computerized construction, architectural practice (Architecture).
Parsons, R.H.—Ph.D. (Oregon State University); cellular physiology, epithelial transport (Science).
Phan, P.—Ph.D. (University of Washington); strategic management, entrepreneurship (Management).
Piper, B.R.—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics (Science).
Sanderson, S.—Ph.D. (University of Pittsburgh); International business, manufacturing policy, and new product development (Management).
Saulnier, G.J.—Ph.D. (Rensselaer Polytechnic Institute); circuits and electronics, communication systems, digital signal processing (Engineering).
Woodhouse, E.J.—Ph.D. (Yale University); policy of science and technology, decision making (Humanities and Social Sciences).

Clinical Associate Professors
Ellis, H.—Ph.D. (University of Connecticut); computer and information sciences (Rensselaer at Hartford).
Grice, R.—Ph.D. (Rensselaer Polytechnic Institute); information usability, human-computer interfaces, applications of computers to technical communication, information development in industry (Humanities and Social Sciences).
Hartley, T.—M.S. (University of Connecticut); database systems, natural language processing, information retrieval (Rensselaer at Hartford).

Heim, J.—Ph.D. (State University of New York at Albany); money and banking, international economics (Humanities and Social Science).

Martyn, T.—Ed.D. (University of Massachusetts); database systems, management information systems, client/server systems (Rensselaer at Hartford).

Mistur, M.—B.Arch. (Rensselaer Polytechnic Institute); architectural design (Architecture).

Triscari, T.—Ph.D. (Rensselaer Polytechnic Institute); information systems (Management).

Younessi, H.—Ph.D. (Swinburne University of Technology); computer and information sciences (Rensselaer at Hartford).

Assistant Professors

Akera, A.—Ph.D. (University of Pennsylvania); history of scientific and technical computing, innovation studies (Humanities and Social Sciences).

Carothers, C.—Ph.D. (Georgia Institute of Technology); computer simulation, parallel simulation, parallel systems (Science).

De, S.—Sc.D. (Massachusetts Institute of Technology); numerical methods in engineering, multimodal virtual environments, fast computational techniques of MEMS (Engineering).

Hart-Davidson, W.—Ph.D. (Purdue University); professional writing theory and practice, usability and participatory design, rhetorical theory, design for the World Wide Web and electronic media, theories and histories of writing techniques (Humanities and Social Sciences).

Hübscher-Younger, T.—Ph.D. (Auburn University); computer-supported collaborative learning; educational technology; human-computer interaction; usability evaluation; software engineering; web application and interface design and development (Humanities and Social Sciences).

Korniss, G.—Ph.D. (Virginia Polytechnic Institute); theoretical and computational physics (Science).

Lonsway, B.—M.Arch. (Columbia University); architectural theory and electronic media (Architecture).

Nelson, M.—Ph.D. (University at Albany, SUNY); information systems (Management).

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); machine learning, computational finance, bioinformatics (Science).

Nambisan, S.—Ph.D. (Syracuse University); information systems (Management).

Nelson, M.—Ph.D. (University at Albany, SUNY); information systems (Management).

Ravichandran, R.—Ph.D. (Southern Illinois University, Carbondale); management information systems (Management).

Thornton, K.D.—M.F.A. (School of the Art Institute of Chicago); art and technology, installation/new media/sculpture (Humanities and Social Sciences).

Torres, R.—Ph.D. (Chalmers Tekniska Hoegskola, Gothenburg, Sweden); architectural acoustics, aurализation of sound fields, subjective effects of room acoustics (Architecture).

Clinical Assistant Professors

Boyer, K.—Ph.D. (McGill University); IT, cities and social change; gender, work, and the politics of technology (Humanities and Social Sciences).

Brown, R.—M.S.E.E. (University of Illinois); computer communication networks, network management, client/server architectures (Rensselaer at Hartford).

Dickinson, L.B.—Ph.D. (Rensselaer Polytechnic Institute); management information systems (Management).

Murtagh, J.P. Jr.—Ph.D. (Rensselaer Polytechnic Institute); investment analysis and financial services (Management).
Robbins, R.W.—M.S. (Binghamton University); accounting, information systems implementation (Management).

Sands, R.—M.S., MBA (University at Albany, SUNY); organizational behavior and human resource management (Management).

Other

Hollinger, D.L.—M.S. (Rensselaer Polytechnic Institute); machine learning, AI applications for the World Wide Web, genetic algorithms, Web programming (Lecturer – Computer Science) (Science).

Kolb, J.—P.E., M.Eng. (Rensselaer Polytechnic Institute); Management of Information Systems (Chief Information Officer, DotCIO) (Management).

Miner, J. - M.S. (Stevens Institute of Technology); information technology management, enterprise computing architectures (Director- IACS, Integrated Administrative Computing Services, DotCIO) (Management).

**Undergraduate Programs**

Designed especially for students with interests outside the technical world, this program nevertheless requires substantial technical talents and skills. Through the synthesis of computing, management, and humanities, this program extends the student's horizons from the focused IT core to the disciplinary knowledge of an application domain (a student-chosen concentration). Also characterizing IT is the integration of traditional education with the spirit of entrepreneurship. Students emerge from this program prepared to pursue a rewarding career or graduate education in a disciplinary field.

**Baccalaureate Programs**

Completion of the B.S. in Information Technology requires a total of 128 credit hours, of which 56 credits constitute an IT Core and 32 credits are devoted to a concentration. The remaining credit hours fulfill Rensselaer degree requirements. The IT core requirements establish a solid foundation for applying IT to any discipline. The Rensselaer requirements ensure the degree’s breadth and its consistency with long-established Rensselaer traditions. The required concentration provides an opportunity for in-depth study of an IT application area. Concentration options include arts, communications and networks, law, management information systems, medicine, psychology, and numerous others. In consultation with a faculty adviser, students may also design their own concentration through the selection of courses that match their individual interests.

The specific requirements for the B.S. in Information Technology are illustrated below.

**Math and Science Requirements: (24 credits)**

- **MATH-1010** Calculus I ........................................................................................................4 credits
- Math Elective ........................................................................................................4 credits
- **CSCI-1100** Computer Science I ..................................................................................4 credits
- **CSCI-1200** Computer Science II ..................................................................................4 credits
- Science Elective ......................................................................................................4 credits
- Science Elective ......................................................................................................4 credits

**Humanities and Social Sciences Requirements: (24 credits)**

- **ITEC-1210** The IT Revolution: Myth or Reality? .............................................................4 credits
- **ITEC-1220** Politics and Economics of IT .......................................................................4 credits
- Humanities Elective ..................................................................................................4 credits
- Social Science Elective .............................................................................................4 credits
- Hum. or Soc. Sci. Elective .........................................................................................4 credits
- Hum. or Soc. Sci. Elective .........................................................................................4 credits
Free Elective Requirements: (12 credits)
- Free Elective .................................4 credits
- Free Elective .................................4 credits
- Free Elective .................................4 credits

IT Core Requirements: (36 or 37 credits)
Pick either the ECSE-2610/ENGR-2960/ECSE-2660 sequence or the CSCI-2300/2500 sequence:
- ECSE-2610 Computer Components and Operations .................................................4 credits
- ENGR-2960 Intro. to the HC-11 Microcontroller 1 .....................................................1 credit
- ECSE-2660 Computer Architecture, Networking, and OS .......................................4 credits
or
- CSCI-2500 Computer Organization .........................................................................4 credits
- CSCI-2300 Data Structures and Algorithms .............................................................4 credits

- ITEC-2110 Exploiting the Information World ..............................................................4 credits

IT Technology Elective (one of):
- CSCI-4380 Database Systems .................................................................................4 credits
- DSES-4530 Information Systems ..........................................................4 credits

- ITEC-4310 Managing IT Resources ........................................................................4 credits
- ITEC-4960 Creative Design in IT 1 ........................................................................4 credits
- ITEC-2210 Intro. to Human Computer Interaction ................................................4 credits

Probability and Statistics Elective (one of):
- DSES-2010 Statistics for Management ..................................................................4 credits
- ENGR-2600 Modeling and Analysis of Uncertainty ................................................3 credits
- MGMT-2100 Statistical Methods .............................................................................4 credits
- PSYC-2310 Experimental Methods and Statistics ................................................4 credits

- ITEC-4100 IT Studio/Capstone Experience .............................................................4 credits

Student-Selected Concentration: (32 credits)
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration course .................................................................4 credits
- Concentration Capstone Experience .........................................................4 credits

1 A special topics course.
The concentrations from which students may choose are as follows:

- **Arts**: Management Information Systems
- **Building Sciences (Architecture)**: Mechanical/Aeronautical Engineering
- **Civil Engineering**: Medicine
- **Communication**: Pre-law
- **Communication and Networks**: Product Design and Innovation (PDI)
- **Computer Hardware**: Psychology
- **Economics**: Science and Technology Studies: Information and Society
- **E-Commerce**: Science Informatics
- **Entrepreneurship**: Special Interest
- **Finance**: Web Technologies
- **Industrial Engineering**: Machine and Computational Learning
- **Machine and Computational Learning**: Management Information Systems

The above list, as well as associated required courses for each concentration, is available on the IT program home page. The list expands as new concentrations are developed. Students wishing to devise a special interest concentration specific to individual interests should consult their faculty adviser.

Each concentration also stipulates an appropriate probability and statistics course for students who pursue it. This course is taken as part of the IT core. Courses that fulfill this purpose include: ENGR-2600, MGMT-2100, PSYC-2310, and DSES-2010.

Below is a typical, but not required, eight-semester course schedule for obtaining the B.S. in IT.

### **First Year**

#### **Fall**

- ITEC-1210 The IT Revolution: Myth or Reality?
- CSCI-1100 Computer Science I
- MATH-1010 Calculus I
- Science Elective

#### **Spring**

- ITEC-1220 Politics and Economics of IT
- CSCI-1200 Computer Science II
- Math Elective
- Science Elective

### **Second Year**

#### **Fall**

- ITEC-2210 Intro. to Human Computer Interaction
- ITEC-2110 Exploiting the Information World Concentration Course
- One of:*
  - ECSE-2610 Computer Components and Operations
- One of:*
  - ENGR-2961 Intro. to the HC11 Microcontroller ..1
  - CSCI-2500 Computer Organization

#### **Spring**

- ITEC-1220 Hum. and Soc. Sci. Elective **
- One of:*
  - ECSE-2660 Computer Architecture, Networking and OS
  - CSCI-2300 Data Structures and Algorithms

- Probability and Statistics Elective (one of):
  - DSES-2010 Statistics for Management
  - ENGR-2600 Modeling and Analysis Uncertainty
  - MGMT-2100 Statistical Methods
  - PSYC-2310 Experimental Methods and Statistics

---

*Students must select either first course in both lists (ECSE) or the second course in both lists (CSCI). Do not select one ECSE and one CSCI.*

**The PDI concentration is 132 credits. Upon completion of this concentration, the student will receive a dual degree with IT and STS. See the H&SS Interdisciplinary Programs and Research Section of the catalog for the eight-semester schedule (pp. 290).**
Only free electives and six credits of the H&SS electives may be taken with the Pass/No Credit option.

If a student chooses to pursue a dual degree with Information Technology as one of the degrees, the dual degree must be the degree that is closest to the Concentration. For example, if a student’s Concentration is Psychology then the dual degree would need to be in Psychology. Currently, Electronic Media, Arts & Communication (EMAC) and Management are not available as a dual degree option.

**Minor Programs**
The IT minor requires four courses:

- One of the following two:
  - ITEC-1210/IHSS-1210 The IT Revolution: Myth or Reality?
  - ITEC-1220/IHSS-1220 Politics and Economics of IT
- ITEC-2110 Exploiting the Information World
- Two of the following four:
  - CSCI-1200 Computer Science II
  - ITEC-2210 Introduction to Human Computer Interaction
  - ITEC-4310 Managing IT Resources
  - PHYS-2050 Science of Information Technology

**Third Year**

**Fall**
ITEC-4310 Managing IT Resources
Hum. and Soc. Sci. Elective **
Concentration Course

IT Elective (one of):
CSCI-4380 Database Systems
DSES-4530 Information Systems

**Spring**
ITEC-4960 Creative Design in IT
Concentration Course

**Fourth Year**

**Fall**
ITEC-4100 IT Capstone Experience
Concentration Course
Hum. and Soc. Sci. Elective **
Free Elective

**Spring**
Concentration Capstone Experience
Concentration Course
Hum. and Soc. Sci. Elective **
Free Elective

**Notes:**

**See Hum. and Soc. Sci. Elective requirements in H&SS section of the catalog.**

1 A special topics course.

3 Cannot be used by CSCI and CSYS majors to satisfy this requirement.

4 Cannot be used by MGMT majors to satisfy this requirement.
**Graduate Program**

Information Technology is the focal point of a revolution in which computer science and computing tools and techniques drive innovation across a wide spectrum of businesses and industries. Rensselaer’s interdisciplinary Master of Science program in Information Technology, distinguished by its currency, intensity and rigor, is educating a cadre of leaders in this revolution.

Rensselaer’s degree is not an overview nor an introduction to the IT field. Students gain a theoretical grounding in computing not often acquired “on the job” and a significant body of course work in a technical IT Concentration area that will qualify them as IT specialists in that field. Rensselaer’s IT graduates are able to “do” as well as “talk about” the application of Information Technology.

The M.S. in IT program prepares students primarily for professional practice in information technology. However, student interaction with Rensselaer faculty who are working on leading-edge IT research has encouraged a significant number of master’s students to seek an IT related Ph.D.

The Rensselaer IT master’s program provides graduates with a breadth of experience in database systems, networking, software design, management of technology, and human computer interaction through the IT Core. In addition, students obtain in-depth experience in the application of information technology by selecting one of nine Concentrations.

The IT program is available through the Troy, N.Y., campus; Rensselaer at Hartford in Hartford, Conn.; and via Professional and Distance Education.

Students seeking admission must have highly competitive academic records and have completed course work that is equivalent to the following Rensselaer courses prior to applying:

- **CSCI-1100 Computer Science I** (number systems, basic computer architecture, stepwise refinement of algorithms, functions and parameter passing, basic programming concepts through two-dimensional arrays, and pointer basics using C++)
- **CSCI-1200 Computer Science II** (pointers, classes, operator overloading, deep vs. shallow copy constructors, inheritance, file I/O, templates in C++, introductory algorithm analysis, and data structures)
- **CSCI-2300 Data Structures and Algorithms** (advanced topics including mathematical induction and its application to algorithm design, linear structures, trees and balanced trees, heaps and priority queues, graphs and graph algorithms)

The GRE is required for applicants requesting full-time study on the Troy campus.

**Master’s Program Requirements**

Students admitted to the M.S. in IT develop an approved plan of study that must include the following:

- Ten courses in IT (a minimum of thirty credits)
- A minimum of six courses (18 credit hours or more) at the graduate level (6xxx-level courses)
- Five Core courses; one from each of the five Core Areas
- A minimum of three courses (nine credit hours or more) in an approved Concentration
- One elective approved by the adviser
- The IT Master’s Capstone course

The Core and Concentration courses are designed to accommodate a wide range of backgrounds. Students can waive an IT Core area requirement and substitute an approved elective only if they have already taken the equivalent of all the courses listed in that Core area. If students have previously completed the basic required Core course, they must then complete the next level required course to add depth in that core
area. For example, if an equivalent course to Database Systems was completed in a prior degree, the Core area requirement could be satisfied by taking Enterprise Database Systems. Students may request transfer credit only for the elective, subject to adviser approval. Additionally, no more than half of all credits used towards the M.S. in IT degree may be taken from courses offered by the Lally School of Management and Technology. These courses are coded MGMT.

The M.S. in IT Master’s Capstone course integrates the knowledge and professional practice of IT Core and Concentration courses. The Capstone utilizes an Information Technology Team Project with a real organization to practice the major concepts of the IT master’s degree. The Team Project involves strategic and business planning, systems development, and technology implementation. Expertise in database systems, networking, software design, decision sciences, management of technology, human computer interaction, and ethics are applied within a framework of global e-business strategy.

Core courses are generally taken in the fall and Concentration courses in the spring. Full-time students normally begin in the fall term and take five courses in the fall and five the following spring to complete the program. Part-time students typically complete the program in two and one-half years of continuous study. Students may elect to extend the program to three semesters enabling the completion of two concentrations (12 courses) and a summer or summer/fall co-op assignment.

Rensselaer currently offers numerous Ph.D. degrees with significant IT related research, e.g. computational chemistry and physics, science and technology studies, decision sciences, applied mathematics and human-computer interaction. Students who are planning doctoral study may choose to apply simultaneously for admission to the Ph.D. in the relevant Rensselaer department and also for the M.S. in IT. Once admitted to both, the student and the Ph.D. and M.S. adviser determine if the regular IT curriculum or the IT Research Track is preferred. If the Research Track is chosen, the student and the adviser select a set of concentration courses that lead to an IT intensive Master’s Thesis in place of the IT Master’s Capstone course.

**IT Core Requirements**

To acquire a breadth of IT experience, master’s degree students take the five Core courses listed below. Alternate courses are also listed for those who have previously completed the required Core course. Courses may be delivered in a variety of modes including on-site, synchronous, asynchronous, and via videoconferencing. Also noted is the usual term in which the required Troy campus Core course is offered. Course offerings change frequently to keep pace with rapid advancement in IT; some courses are delivered in alternate years. Please see the Troy IT Web site for the most current information: [www.it.rpi.edu](http://www.it.rpi.edu).

Students enrolling at the Hartford campus or via Rensselaer’s Professional and Distance Education program should consult the following Web sites for course availability:

- Hartford: [http://www.rh.edu/](http://www.rh.edu/)
- Professional and Distance Education: [http://www.pde.rpi.edu/](http://www.pde.rpi.edu/)

<table>
<thead>
<tr>
<th>IT Core Area</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Systems</td>
<td>CSCI-4380 Database Systems</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td>Networking</td>
<td>ECSE-4670 Computer Communication Networks</td>
<td>Fall</td>
</tr>
<tr>
<td>Software Design</td>
<td>ECSE-6770 Software Engineering I</td>
<td>Fall</td>
</tr>
<tr>
<td>Management of Technology</td>
<td>ENGR-6100 Business Issues for Engineers and Scientists</td>
<td>Fall</td>
</tr>
<tr>
<td>Human Computer Interaction</td>
<td>COMM-6420 Foundations of HCI Usability</td>
<td>Fall</td>
</tr>
</tbody>
</table>

**IT Advanced Core**

Students who have already completed the Core courses listed above select an advanced course, subject to adviser approval. Typical selections are:

<table>
<thead>
<tr>
<th>Advanced Core</th>
<th>Course Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database Systems</td>
<td>DSES-6520 Enterprise Database Systems</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6460 Advanced Database Management Topics</td>
<td>Spring</td>
</tr>
</tbody>
</table>
Concentration Requirements

The IT faculty designed the IT Concentrations to provide an in-depth, leading-edge experience in the application of information technology. Students often select areas that complement their prior backgrounds (e.g., students with strong computer backgrounds may select MIS or e-business). Alternately, some students select an Concentration related to their prior backgrounds and then expand on that background through higher-level course work. The course taken to complete a Core requirement does not count toward the Concentration.

Rensselaer’s course offerings are dynamic and new courses are developed each semester, making course listings subject to change.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>Course Number and Name</th>
<th>Term(s) Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Networking</td>
<td>Select three of the following courses:</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-4220 Network Programming</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECSE-6660 Broadband Networks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECSE-6670 Local Computer Networks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ECSE-6600 Internet Protocols</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All three of the following courses are required:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COMM-6760 Electronic Coaching Systems</td>
<td>Spring</td>
</tr>
<tr>
<td>Human-Computer Interaction</td>
<td>COMM-6750 Communication Design for the WWW</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>COMM-6810 Studio Design in HCI</td>
<td>Spring</td>
</tr>
<tr>
<td>Database Systems Design</td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSCI-4020 Computer Algorithms</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6460 Advanced Database Management Topics</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6930 Database Mining</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>DSES-6180 Knowledge Discovery with Data Mining</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>DSES-6520 Enterprise Database Systems</td>
<td>Spring</td>
</tr>
<tr>
<td>Software Design</td>
<td>Select three of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MGMT-6170 Advanced Systems Analysis and Design</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-4440 Software Design and Documentation</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6090 Generic Software Design</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-6320 Graphical User Interfaces</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>ECSE-6780 Software Engineering II</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>DSES-6810 Studio Design in HCI</td>
<td>Spring</td>
</tr>
<tr>
<td>Information Systems Engineering</td>
<td>Select a second course in Database Systems or Software Design</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>Select two more of the following courses:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSES-6500 Information and Decision Technologies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for Industrial and Service Systems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSES-6570 IT and Systems for E-Business</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>DSES-6560 IT and Systems for Enterprise Engineering</td>
<td>Fall</td>
</tr>
<tr>
<td>Management Information</td>
<td>DSES-6530 Decision Support and Expert Systems</td>
<td>Spring</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>DSES-6620 Discrete Event Simulation</td>
<td>Fall</td>
</tr>
<tr>
<td>Systems</td>
<td>Select three of the following courses: ¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MGMT-6170 Advanced Systems Analysis and Design</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>MGMT-6180 Strategic IS Management</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>MGMT-6810 Management of Technical Projects</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>MGMT-4130 Enterprise Information Architecture</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>MGMT-6710 Designing, Developing and Staffing of High Performance Organizations I</td>
<td></td>
</tr>
<tr>
<td>E-Business</td>
<td>MGMT-6120 Fundamentals of E-Business and/or</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>DSES-6570 IT and Systems for E-Business</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>Select two of the following courses: ¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MGMT-6690 Supply Chain Mgmt. For E-Business</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>MGMT-6200 Marketing and the WWW</td>
<td>Fall/Spring</td>
</tr>
<tr>
<td></td>
<td>ECSE-6600 Internet Protocols</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>DSES-6180 Knowledge Discovery with Data Mining</td>
<td>Spring</td>
</tr>
<tr>
<td>Bioinformatics</td>
<td>BIOL-6410 Bioinformatics I: Biological Sequence Analysis</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>BIOL-6420 Bioinformatics II: Molecular Modeling</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6390 Database Mining or</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>CSCI-6210 Design and Analysis of Algorithms</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>Select one of the following electives: ²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DSES-6180 Knowledge Discovery with Data Mining</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>BIOL-69xx Molecular Basis of Biotechnology</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CHEM-4330 Drug Discovery</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6460 Advanced Database Management Topics</td>
<td>Spring</td>
</tr>
<tr>
<td>Research Track</td>
<td>CSCI-6390 Database Mining</td>
<td>Fall</td>
</tr>
<tr>
<td>(Example from Chemistry)</td>
<td>CHEM-6510 Computational Chemistry</td>
<td>Spring</td>
</tr>
<tr>
<td></td>
<td>CSCI-6100 Machine and Computational Learning</td>
<td>Fall</td>
</tr>
<tr>
<td></td>
<td>ITEC-6990 Master’s Thesis (in place of IT Capstone)</td>
<td>TBD</td>
</tr>
</tbody>
</table>

**IT Capstone Requirement**

<table>
<thead>
<tr>
<th>Course Number and Name</th>
<th>Term Offered</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITEC-6800 IT Master’s Capstone</td>
<td>Spring</td>
</tr>
</tbody>
</table>

¹ A maximum of five management courses (code: MGMT) may be taken towards the IT degree.
² Additional electives available subject to approval.
Table of Contents

<table>
<thead>
<tr>
<th>Program</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree Programs Offered</td>
<td>308</td>
</tr>
<tr>
<td>Overview of Undergraduate Programs</td>
<td>308</td>
</tr>
<tr>
<td>Overview of Graduate Programs</td>
<td>311</td>
</tr>
</tbody>
</table>
Lally School of Management and Technology

Dean: Denis F. Simon

Assistant Dean, Undergraduate Programs: Robert Sands

Director, MBA/M.S. Programs (Academic Services): (vacant)

Associate Director, MBA/M.S. Programs (Student Services): Christine M. Johannesen

Director, MBA/M.S. Admissions: Frank J. Mendelson

Director, Ph.D. Program: Lois S. Peters

Lally School Home Page: http://lallyschool.rpi.edu

Rensselaer’s Lally School is focused on training students who have a passion for transforming commercially relevant ideas and concepts into new products and services. Our graduates are aspiring business leaders and entrepreneurs who understand the power of technology as well as the creative processes that produce successful innovation.

As a student you will:

- Develop the skills to integrate technology across business functions for commercial results.
- Acquire “real-world” experience through study that emphasizes hands-on projects and teamwork from day one.
- Leverage Rensselaer’s resources to network, learn, and position yourself to capitalize on the business opportunities of tomorrow.

Tapping into Rensselaer’s interdisciplinary advantage, Lally students have access to the business school’s highly respected international faculty as well as the students and faculty from architecture, engineering, humanities and social sciences, information technology, science, the Rensselaer Incubator, the Rensselaer Technology Park, the Severino Center for Technological Entrepreneurship, and the Center for Financial Technology.

The Lally School offers six areas of educational specialization and research for students.

- Technological entrepreneurship
- Management of information systems
- Finance
- Marketing and new product development
- Production and operations management
- Environmental management and policy (graduate-level only)

Lally also has dual-degree offerings in conjunction with the information technology program and the schools of architecture, engineering, humanities and social sciences, and science.

The Lally School and its faculty are organized into two departments, with a residential program based in Troy, N.Y., and a primarily non-residential campus focused on “education for working professionals” in Hartford, Conn. The Troy campus also includes Lally’s Office of Executive Programs, which administers
the Executive MBA program for working managers as well as a number of customized executive-education programs for the school’s corporate partners at home and abroad.

**Degrees Offered**

Management B.S., M.S., MBA, Ph.D.

**The Lally Undergraduate Program**

The undergraduate program at Rensselaer’s Lally School draws heavily on Rensselaer’s strengths in engineering, science, technology, and entrepreneurship. Within these programs, the Lally School provides a balance between theory and practice and between rigor and relevance. Additionally, there is a strong emphasis on the application of knowledge through team-based projects and a focus on the intersection of entrepreneurship and innovation.

Goals for the baccalaureate program in management include:

■ Preparing students for professional careers in technology-driven organizations.
■ Core management practices and an in-depth understanding in a specialized area.
■ Theories, concepts, and techniques to solve problems and make effective decisions.
■ Critical-thinking skills and the ability to adapt to a rapidly changing technological world.
■ A high standard of ethics and responsibility in personal affairs and professional life.
■ Competencies in utilizing information technology.
■ Global thinking and working in a multi-cultural setting.

Course work infuses integrative business concepts with technological knowledge and prepares students for careers in the fields of information systems, management of R&D, technical sales, risk assessment, new product development, and marketing. Analytic and quantitative methodologies are introduced in specialized technical courses that build on cases and examples introduced in other classes. Students learn to associate the development of technology with increases in organizational effectiveness and efficiency.

The management core sequence emphasizes basic skills in the traditional business areas of finance, marketing, human behavior, computing, and organizational analysis and development. The math and science sequence provides a strong background in quantitative skills, while humanities and social sciences course work heightens the student’s appreciation for significant societal issues. Throughout the program, the topics introduced in the various courses are integrated.

This four-year B.S. in Management program requires a minimum of 124 credit hours. A typical program is described below.

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit Hours</th>
<th>Spring</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1500 Calculus for Management</td>
<td>4</td>
<td>MATH-1520 Math Methods in Management</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-2510 Microcomputers and Applications</td>
<td>4</td>
<td>Economics</td>
<td>4</td>
</tr>
<tr>
<td>MGMT-1100 Introduction to Management</td>
<td>4</td>
<td>CSCI-1010 Intro. to Computer Programming</td>
<td>4</td>
</tr>
<tr>
<td>Humanities or Social Science</td>
<td>4</td>
<td>MGMT-1260 External Environment of Business</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>Humanities or Social Science</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>
Concentrations
Students are encouraged to select one or more concentrations in order to provide further depth in an area of student interest. The concentrations and their associated courses are as follows:

**Financial Systems**
- MGMT-4320 Investments I
- MGMT-4330 Investments II
- MGMT-4340 Advanced Corporate Finance
- MGMT-4370 Risk Management

**Marketing**
- MGMT-4470 Marketing Research
- MGMT-4490 Advertising Strategy and Promotions
- MGMT-4460 Consumer Behavior and Product Design

**Management Information Systems**
- MGMT-4240 Systems Analysis and Design
- MGMT-4160 Telecommunications for Business
- MGMT-4960 Data Resource Management

**Technological Entrepreneurship**
- MGMT-4520 Introduction to Technological Entrepreneurship
- MGMT-4510 Invention, Innovation, and Entrepreneurship
- MGMT-4530 Starting Up a New Venture

**Restricted Elective (choose one from three below)**
- MGMT-4130 Enterprise IT Integration
- MGMT-4150 IT Project Management
- MGMT-4550 Business Models for Digital Enterprise
Minor Programs
The Lally School also offers undergraduate minor programs for management students or Rensselaer students majoring in other fields. Lally students also may pursue a minor outside of the management school. Management majors typically use electives in their program as minor course work in complementary fields such as communications, computer science, economics, industrial and management engineering, or psychology. However, students can elect to pursue interests in any Rensselaer school.

The following minors are offered by the Lally School and require a minimum of 16 credit hours. Each student’s designated minor adviser can approve course substitutions to meet individual student needs.

Management and Technology Minor
The minor in management and technology usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-2300 Accounting for Decision Making
- MGMT-2320 Managerial Finance
- Restricted Elective (see minor adviser)

Technological Entrepreneurship Minor
The minor in technological entrepreneurship usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-4520 Introduction to Technological Entrepreneurship
- MGMT-4510 Invention, Innovation, and Entrepreneurship
- MGMT-4530 Starting Up a New Venture

Marketing Minor
The minor in marketing usually consists of the following four courses:
- MGMT-1100 Introduction to Management
- MGMT-4430 Marketing Principles
- MGMT-4470 Marketing Research
- MGMT-4490 Advertising Strategy and Promotions
  or
  MGMT-4460 Consumer Behavior and Product design

Dual or Double Major Programs
To develop skills in other areas of interest or in preparation for careers related to specialized topics, students may pursue a dual or double major with other non-management curriculum.

Such options can be arranged with the information technology program or within the schools of engineering, science, architecture, or humanities and social sciences.

Special Undergraduate Opportunities
The Lally School offers four additional programs to meet undergraduate needs in the areas of research, law, international business, and co-operative education.

Undergraduate Research Program (URP)
Through the URP, students have the opportunity to work with a faculty adviser on tangible research projects. Students are eligible for a Summer Research Fellowship stipend under a program sponsored by the Office of Undergraduate Education. The stipend is intended to cover 10 weeks of full-time research.

Accelerated Management-Law Program
In cooperation with Albany Law School of Union University and Columbia University Law School, Rensselaer offers a unique program leading to a B.S. and a Juris Doctor (J.D.) in six years rather than seven. Admission to this program is restricted, with most students admitted as incoming freshmen. Selected applicants must also meet the admission requirements of Albany Law School of Union University. Thus, a prospective management-law student may be able to assure admission to law school prior to beginning an undergraduate career at Rensselaer. Transfer into the management-law program from other Rensselaer curricula is limited to students who have demonstrated academic excellence.
Although guaranteed admission to Albany Law School is available to selected incoming freshmen, conditional admission also is available to students accepted by Rensselaer who meet specified achievement levels in their undergraduate program. In addition, Rensselaer has established a working relationship with Columbia University Law School that allows a gifted management-law student to become a candidate for admission after his or her third year at Rensselaer, if a committee within the Lally School nominates the student. Rensselaer’s inclusion in Columbia’s Accelerated Interdisciplinary Legal Education Program (AILE) has made this opportunity possible. Management-law students also have applied successfully for early admission to Harvard, Stanford, Cornell, and the University of Virginia. The Lally School is committed to assisting each student attain their individual educational goals and objectives.

International Management Exchange Program
Rensselaer’s Lally School has agreements with more than 15 schools in 13 countries for the exchange of qualified students from and to the Rensselaer campus. This exchange occurs for one semester in the third or fourth year of undergraduate studies and/or in the fall semester in the second year of graduate studies. The foreign schools chosen for the exchange program are renowned in the field of management education. Students interested must demonstrate superior academic records, maturity, and in some cases, the necessary language capabilities to be selected for the exchange program.

For more information about this program, contact the International Exchange Program Coordinator, at (518) 276-2388 or e-mail sandsr@rpi.edu or maceyb2@rpi.edu.

Cooperative Education
Rensselaer’s Cooperative Education Program and the Lally School offer pre-professional work experience for undergraduates. As part of the co-op program, students work one semester and one summer in industry, business, and government positions. The co-op assignment usually occurs during the junior or senior year and can sometimes be scheduled to permit the student to graduate with the class in which he or she matriculated. Typical job opportunities are in the fields of accounting, finance, management systems, and information systems. The co-op program is described in detail in the Student Life section of this catalog.

For more information on any aspect of the undergraduate management and technology program, contact sandsr@rpi.edu.

The Lally Graduate Programs
Rensselaer’s Lally School offers three graduate programs: a Master of Science in Management, a Master of Business Administration, and a doctoral program in Management and Technology.

The M.S. in Management builds around a specific focal area and is best suited for students with a clearly defined career goal. The degree allows students with technical expertise to develop broader career options that include project management and the ability to apply business methods in a specialized area.

The Lally MBA provides students with breadth and depth in managerial skills and technological acumen. In addition to the mainstay MBA program, the Lally School offers three additional tracks. The Executive MBA is a two-year, weekend-based, intensive study for working professionals. The Sino-U.S. MBA addresses the needs of Chinese and foreign companies establishing and expanding businesses in China. The J.D.-MBA allows a student to simultaneously pursue a law degree and an MBA degree.

The Lally Ph.D. in Management and Technology is a research-oriented academic program. Students develop a scholarly specialization in one of six core areas and graduates generally pursue a career path in either academia or research.
The Lally School also provides an array of support services to students throughout their studies. The Graduate Student Services staff assist with orientation, academic advising, career development, employment preparation, and job placement opportunities. Other resources include the Severino Center for Technological Entrepreneurship and the Graduate Management Student Association. Activities within these organizations include a business etiquette dinner, a team-building ropes course, the Tech Valley Collegiate Business Plan Competition, the Distinguished Speaker Series, the Rensselaer Entrepreneurship Interns Program, the Biotech Club, and an alumni networking wine-tasting social. Additional information on these activities may be found at http://lallygrad.mgmt.rpi.edu/index.asp.

Co-op and internship experiences are available to all Lally graduate students. Co-ops are arranged through the Rensselaer Career Development Center’s (CDC) co-op office and work experience should be related to a student’s degree program. The co-op must be approved by a student’s academic adviser. Internships are arranged through the CDC, Lally Career Resources, or by the student. They can be taken as a full-time summer job and/or as a part-time job during the academic year.

Co-op job opportunities are varied, depending on the student’s skills and area of specialization, and are available in business, industry, and government. Lally students have been on co-op assignments at a variety of firms including General Electric, Kodak, Pratt and Whitney, and Boeing, as well as in start-up companies and small- and medium-sized local businesses.

Rensselaer requires all students to be full-time and in residence for at least nine months in order to participate in a co-op experience. Students also must have at least 12 credits remaining in their program at the conclusion of the co-op in order to participate. The structure of the MBA program enables students to complete a full-time co-op during the summer semester after their first nine months of study. Students are expected to return in the fall semester as full-time students. However, if the opportunity to continue the co-op exists, the student may continue working on a part-time basis while registered as a full-time student through the fall term by applying for a co-op extension. The Lally Graduate Student Services, the CDC, and the International Student Services office must approve a co-op or internship for any international student prior to accepting an offer.

**Master of Science in Management**

The M.S. in Management is a specialized 30-credit program that may be pursued on a part- or full-time basis. The program is designed for students who wish to concentrate their studies in a particular area. The criteria for candidates completing the M.S. program are as follows:

- The academic program must specialize and focus on management and technology.
- The approved plan of study must include four core courses covering finance, marketing, quantitative analysis, and organizational behavior or human resource management. In addition, a concentration consisting of four sequential courses is required, as well as one elective course.
- The conclusion of the academic program must include a culminating experience. The recommended course is MGMT-6680 Strategy Technology and Global Competitive Advantage.

**Concentrations in the Master of Science Program**

A concentration consists of a 12-credit sequence of related courses. Concentrations aid students in marketing themselves to employers for internship opportunities or for employment opportunities upon graduation. All M.S. diplomas specify management as the discipline of study; however, the concentration is not identified.
M.S. Concentrations

- Strategy and technological entrepreneurship
- Management of information systems
- Finance
- New product development and marketing
- Production and operations management
- Environmental management and policy

Management concentrations are based on student interest and will vary over time in response to strategic business and technological developments. For a list of M.S. concentrations with their associated courses, visit http://lallygrad.mgmt.rpi.edu/concentration.

Master of Business Administration

The MBA is the Lally School’s premier program and offers students both depth and breadth in management education with an emphasis on business innovation and entrepreneurship.

The curriculum provides a strong grounding in managerial fundamentals while highlighting the role that technology plays in business development and competitive advantage. This 60-credit residential MBA is a comprehensive 21-month program.

In the first nine months of the program, students take fundamental business courses that provide them with the tools and capabilities expected of all managers in a professional capacity. A summer work experience is an important part of the MBA program. Options include working for companies ranging from Fortune 500’s to local start ups associated with the Rensselaer Entrepreneurship Interns Program (REIP).

In the final nine months of study, students complete three more fundamental business courses, including a two-course strategy capstone sequence and a course covering ethical, political and legal aspects of business. The remaining courses are comprised of select elective courses from one of the six designated MBA concentrations.

The core courses in the MBA program are as follows:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT-696x</td>
<td>Statistical Concepts and Methods for Managers (Orientation)</td>
<td>MGMT-696x</td>
<td>Corporate Finance and Governance</td>
</tr>
<tr>
<td>MGMT-6962</td>
<td>Decision Making Models for Management</td>
<td>MGMT-6520</td>
<td>Design, Manufacturing, and Marketing II</td>
</tr>
<tr>
<td>MGMT-6190</td>
<td>Financial and Managerial Accounting</td>
<td>MGMT-696x</td>
<td>Microeconomics in Global Perspective</td>
</tr>
<tr>
<td>MGMT-696x</td>
<td>Macroeconomic and Financial Environment of Business</td>
<td>MGMT-6800</td>
<td>Ethical, Political, and Legal Context of Business</td>
</tr>
<tr>
<td>MGMT-6510</td>
<td>Design, Manufacturing, and Marketing I</td>
<td>MGMT-6650</td>
<td>Technology and Competitive Advantage (capstone)</td>
</tr>
<tr>
<td>MGMT-6965</td>
<td>Behavior in Technology Intensive Organizations w/Lab</td>
<td>MGMT-6660</td>
<td>Strategy, Technology, and Entrepreneurship (capstone)</td>
</tr>
<tr>
<td>MGMT-6140</td>
<td>Information Systems for Management</td>
<td>MGMT-696x</td>
<td>Gary Craig ’68 Career Seminar (required both fall and spring)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The remaining courses in the 60-credit program include eight electives (24 credits):

- One (three credit) elective in the first nine months of study.
- Seven electives (21 credits) in the last nine months of study, one focused on International Business issues.

**The DMM Sequence**

The centerpiece of Lally’s innovative MBA program is the core course sequence in Design, Manufacturing, and Marketing I and II. The DMM experience is a year-long integrated team-based product-development course that is widely recognized as a unique educational experience. Under the leadership of a team of cross-disciplinary faculty, teams of students develop a new product and follow the new-product development process from conception to planning for commercialization. Utilizing Rensselaer’s technological resources, team projects may have the opportunity to become a capitalized venture with an eventual destination in the Rensselaer Incubator or Technology Park. Recent DMM start-ups include Request.com, Teircent Corporation, and Orca Gear Incorporated. The DMM milestones are outlined below:

**DMM I & II—Milestone Overview**

*First 14 Weeks: Milestone I*
- Market Structure
  - Customer Market
  - Target Market
- Product Idea Generation
- Casing the Competition
- Legal Propriety
- Concept Testing
- Understanding Buyer Needs

*Second 14 Weeks: Milestones II & III*
- Product Design
- Product Manufacturing
- Manufacturing Costs/Sales
- Current Market
- Marketing Strategy
- Product Launch

Future Opportunities for DMM Teams include business plan competitions, the Rensselaer IDEA Lab, the venture B-Plan series, the Rensselaer Incubator, and the Rensselaer Technology Park.

MBA students may wish to select a concentration from the six concentration options listed below, or they may develop a customized management and technology concentration in conjunction with their adviser.

**MBA Concentrations**

- Strategy and technological entrepreneurship
- Management of information systems
- Finance
- New product development and marketing
- Production and operations management
- Environmental management and policy

Lally graduate students can take courses in other Rensselaer schools as a part of the Lally School’s interdisciplinary initiative.

Full-time MBA students have the opportunity to participate in Lally’s International Exchange Program after completing 12 months of the MBA program. A semester in a leading Western European or Asian business school is available to students wishing to expand their global network.
Dual Master’s Programs

The dual degree option offers students the opportunity to receive two master’s degrees from Rensselaer. It is an opportunity to combine technical expertise from the information technology program or the schools of engineering, science, architecture, and humanities and social sciences, with a management M.S. or MBA degree in a shorter period of time than if pursued independently.

The joint MBA program allows a student to complete both degrees by taking a total of 72 credit hours (an MBA alone is 60 credits, and most M.S. degree programs are 30 credits). Upon acceptance to both programs, students confer with academic advisers in both disciplines to determine the plan of study. Plans of study are submitted for both degree programs and separate diplomas reflect a degree in each discipline. Additional dual degree options combine two 30-credit M.S. programs. Joint M.S. programs allow the student to receive two master’s degrees by completing 54 credit hours.

J.D.-MBA Program

In collaboration with Albany Law School of Union University, a student may simultaneously pursue an MBA and J.D. degree. By integrating the programs, some courses at one institution are applied toward the degree requirements at the other. This arrangement reduces the total time required for both degrees by at least one semester. Interested candidates must apply to and be accepted at both institutions. Additional information concerning the MBA requirements can be obtained from the Lally School. This program is separate and distinct from the undergraduate management-law program.

Sino-U.S. Programs

The Lally School has initiated several programs that allow students to develop an understanding of the management and technology practices appropriate to Chinese business conditions. Among the programs offered at Rensselaer are:

■ Sino-U.S. MBA in Management and Technology—This program was initiated in 1995 and is designed to develop cross-cultural managers for multinational companies operating in China. Students follow a similar curriculum to that of other MBA students as part of this 21-month program.

■ Certificate Programs—Specialized executive programs for working professionals from China in such areas as “The Management of Software Development Firms.”

■ Sino-U.S. Center for China Enterprises Strategic Studies (SUCCESS)—This on-campus research center is dedicated to the analysis of small- to medium-sized enterprises operating in China. Activities include study trips to China, hosting visiting professors from China, and supporting doctoral-level research.

■ Specialized M.S. in Management—This option offers concentrations in management of power utilities, software firm management, management of technology and R & D, and international business strategy.

Executive Master of Business Administration (EMBA)

The Lally school offers an Executive Master of Business Administration designed for individuals who possess significant (more than six years) management experience. Its unique format of meeting alternate Fridays and Saturdays over the course of two academic years allows students to continue their normal career activities and immediately apply the techniques and ideas learned throughout the program. Lally School senior faculty provide instruction for EMBA’s technically oriented management curriculum, which takes advantage of the Institute’s strengths in scientific and technological education and research. The program is cohesive; each course builds upon previous courses while laying the foundation for upcoming courses. In addition, all members of an EMBA class take classes together during the two-year time period. Between the first and second year of the program, the students take part in a three-day residency in Washington, D.C., which focuses on government-business relations.
Doctoral Programs
The Ph.D. in Management and Technology is a research-based program concentrating on scholarship in the following core areas:

- Entrepreneurship
- Innovation
- New product development
- Information technology
- Financial technology
- International business and global management of technology

Students are expected to develop scholarship in one of Lally’s areas of interdisciplinary focus and be conversant in a tradition business discipline. The Ph.D. program emphasizes research methods and an appreciation of relevant theoretical and empirical literature in the student’s area of concentration. The program strives to balance theoretical approaches with empirical studies that can be applied to real-world challenges. Graduates of the doctoral program typically pursue academic and research positions at well-respected institutions in the United States and abroad.

Core Requirements
Through courses taken prior to admission or courses within the doctoral program, management Ph.D. students must demonstrate knowledge that covers basic management areas, such as marketing, finance, and organizational behavior. In addition to area content courses, students are expected to take courses related to Lally’s thematic focus areas. The doctoral adviser and committee evaluate each student and specify any courses needed to fulfill this breadth and depth requirements. Each semester, the student is expected to take a selected number of doctoral-level seminars offered by the Lally School.

In addition, all doctoral students must take a three-course research methodology sequence and a two-course sequence in advanced statistical techniques. Since the doctoral degree is research oriented, the student must complete a research paper as part of the research-methods course sequence. In consultation with their faculty adviser, students normally submit an outline of their goals and a plan of study by the second year. The plan indicates courses the student intends to use, including thesis credits, to meet the 90-credit graduation requirement. The student’s past experience and study may allow for considerable flexibility in plan development. By the third year, the student is expected to complete a field exam. This is followed by a candidacy exam and a final defense.

Concentrations
Research programs and concentrations are developed through tutorial relationships with faculty. They include traditional disciplines such as finance, marketing, and organization, as well as interdisciplinary programs such as international business, financial technology, entrepreneurship, environmental management, and new product development. Candidates are encouraged to combine fields; for example, entrepreneurship, management of information systems, and the strategic uses of technology.

Students choose specific courses in consultation with the Ph.D. director, concentration area advisers, and members of the research committee. They also may petition the doctoral committee for a program of advanced studies and research not included in the above. Faculty in the student’s area of desired expertise will prepare the field examination, which includes a written and oral examination. For information concerning the requirements for a typical program of study, applicants should contact the director of the Ph.D. programs.
The appropriate faculty evaluate a student’s progress yearly. Depending on the candidate’s stage of development in the program, criteria of evaluation include:

- Performance in the doctoral research seminars and the required methodology courses.
- Appropriate plan of study.
- Coursework/thesis registration.
- Successful completion of the field exam.
- Formation of doctoral committee.
- Completion of candidacy exam.
- Identified goals, expectations, accomplishments, and career path.

Students failing to satisfy the requirements of the annual evaluations will be terminated from the management doctoral program.

Once students choose their dissertation topic, the student adviser recommends a doctoral committee for that student to the Office of Graduate Education. This recommendation is based on the student’s desires and objectives within the plan of study. Before completing 75 credit hours of graduate study, each student will prepare a research proposal consisting of a problem statement, supporting literature, proposed research methodology, and anticipated results. The presentation of this research topic to the academic community, followed by an examining session conducted by and limited to the student’s doctoral committee, will comprise the candidacy examination. A student will be admitted to candidacy upon satisfactory performance of the candidacy examination and by meeting the requirements in designated core disciplines (through their study in the concentration or program area and through the preparation of a research paper).

The culmination of doctoral studies is the dissertation, which represents the results of an original investigation and demonstrates capacity for independent research. The candidate’s studies lead to the dissertation and include participation with faculty in research activities. This participation may form the basis of the dissertation topic. Participation in these projects should enable the student to structure, engage in, and report on a research endeavor concerned with management processes. This is a requirement that must be satisfied prior to the admission to candidacy. Students will present the results of their dissertation research to the Rensselaer community and be examined by their doctoral committees. Upon satisfactory completion of this examination (and university requirements), students will be awarded the doctoral degree in management.

**Research Initiatives**

Research at the Lally School is characterized by its cross-disciplinary, multiplatform, and international nature. Faculty at the Lally School conduct research in China, Britain, Scandinavia, Italy, France, Germany, Argentina, Mexico, Chile, Singapore, Australia, Canada, and the United States. While the issues investigated cut across functional areas in a business setting, are longitudinal in scope, and involve a variety of academic disciplines, the objective is to produce rigorously developed theories and empirical studies that are at the frontiers of new management knowledge and that pass the stringent tests of double-blind academic peer review.
Research conducted by the Lally School is often featured at conferences sponsored by the Academy of Management, INFORMS, PICMAN, Academy of International Business, and ASSA. In addition, the Lally School regularly sponsors international conferences and seminars designed to bring together the best academics globally to focus on emerging areas of new research in order to establish intellectual leadership in a domain of broad interest to the academic community.

The Lally School has five intersecting research categories that are recognized for their leadership position in the academic community. They seek to create new frontiers of managerial thought in the area of technology and entrepreneurial management. The five Lally research categories are as follows:

**Technological Entrepreneurship**
At Rensselaer, technological entrepreneurship is the process of converting technical ideas into new businesses in startup ventures and established firms. This is the primary research focus for more than 15 faculty engaged in collaborative, multidisciplinary projects. These faculty members examine technological entrepreneurship from many perspectives, including psychology, economics, and sociology. They focus on such problems as opportunity identification, accelerating new-venture creation, intellectual property and governance in high-technology startups, and managing hyper-growth firms. The Severino Center for Technological Entrepreneurship is the focal point for scholarship in entrepreneurship and serves as a bridge to the Rensselaer Incubator and Rensselaer Technology Park.

**New Product Development and Radical Innovation**
In this arena, researchers concentrate on understanding the management processes leading to the development of successful new products. Research topics include consumer and business marketing, intellectual property management, managing innovation, and identifying breakthroughs from a marketing standpoint. Related research focuses on how managers in medium- and large-sized organizations manage radical, breakthrough innovations and compares these practices to those associated with incremental, continuous-improvement types of new product-development processes.

**Management Information Systems**
This area focuses on the role and use of information technology in organizations and how it transforms the theories and practice of management. The research incorporates theories and concepts from such fields as computer science, economics, psychology, communications, and organization theory. Of particular interest are topics that relate to supply-chain management, business and consumer marketing, virtual collaboration, distributed innovation, and internal organizational capabilities. The Lally School adopts an interdisciplinary approach to researching new business models and the issues that present challenges and opportunities for managers in IT, entrepreneurship, finance, marketing, and innovation.

**Financial Technology**
This emerging field of scholarship and practice combines the traditionally distinct disciplines of finance, information technology, and modeling. Formed within this field are three relatively distinct applications. The first application is the impact of technology on financial institutions, financial markets, and corporate financial management. This area focuses on the interface between technological shifts and practice in the financial services industry and the functioning of capital markets. The second application pertains to the financing of new technological ventures and high technology. This area focuses on private equity; venture capital markets; and the implications for regulatory, macroeconomic, and firm-level influences on industry development. The above two areas of research are further explicated by a third research specialty in computational finance or financial engineering.
Global Management of Technology

driven by the rapid onset of globalization, the processes of technological discovery, innovation, and commercialization have become transnational in nature. On-going research in this area at the Lally School focuses on two specific issues. First, it seeks to better understand how the emergence of new centers of technological capability outside of the United States, Europe, and Japan affects decisions regarding the location of R&D and high-value-added manufacturing processes by global managers. Secondly, this research seeks to learn more about the specific strategic and operational challenges associated with managing the creation and application of new knowledge in a multinational firm with critical facilities in several different regions around the world. By gaining a deeper appreciation of the impact of globalization on innovation and R&D, it is hoped that managers can develop a more international perspective on where and how to access technical resources for enhancing their competitive advantage.

Troy Campus Faculty*

**Professors**

Baron, R.A.—Ph.D. (University of Iowa); organizational behavior, entrepreneurship (Dean R. Wellington ’83 Professorship in Management).

Berg, D.—Ph.D. (Yale University); management of technological organizations, policy issues of research and development in the service sector (Institute Professor of Science and Technology).

Haddock, J.—Ph.D. (Purdue University); modeling of production and service systems including simulation and optimization techniques.

Hasan, I.—Ph.D. (University of Houston); finance.

Judd, G.—Ph.D. (Rensselaer Polytechnic Institute); strategy, materials engineering.

Norsworthy, J.R.—Ph.D. (University of Virginia); economics, business economics.

Paulson, A.S.—Ph.D. (Virginia Polytechnic Institute); operations research and statistics, risk management and investment analysis (Frank and Lillian Gilbreth Professor in the Technologies of Management).

Simon, D.—Ph.D. (University of California, Berkeley); international business strategy, global management of technology, and China business and technology issues. (Dean)

Simons, G.R.—Ph.D. (Rensselaer Polytechnic Institute); industrial and management engineering, production and operations management, project planning and control, manufacturing systems.

**Clinical Professors**

Abetti, P.A.—PE., Ph.D. (Illinois Institute of Technology); management of technology, international business development and strategic planning, entrepreneurship.

Hughes, G.—Ph.D. (Princeton University); strategy, entrepreneurship, information technology.

**Associate Professors**

Durgee, J.F.—Ph.D. (University of Pittsburgh); marketing research and advertising.

Goldenberg, D.H.—Ph.D. (University of Florida); investments, derivatives markets, mathematical and computational finance.

Leifer, R.P.—Ph.D. (University of Wisconsin); organizational behavior and organizational design, management information systems.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
McDermott, C.—Ph.D. (University of North Carolina, Chapel Hill); manufacturing strategy, operations management.

Peters, L.S.—Ph.D. (New York University); science and technology policy, innovation and R&D management, entrepreneurship, organization theory, international business.

Phan, P.—Ph.D. (University of Washington); strategic management, entrepreneurship (Warren H. Bruggeman ’46 and Pauline Urban Bruggeman Distinguished Associate Professor).

Ravichandran, T.—Ph.D. (Southern Illinois University, Carbondale); management information systems.

Sanderson, S.—Ph.D. (University of Pittsburgh); international business, manufacturing policy, new product development.

Veryzer, R.—Ph.D. (University of Florida); marketing and consumer behavior.

Clinical Associate Professors

Miccio, R.—J.D. (Albany Law School); law, ethics.

St. John, W.C.—Ph.D. (Rensselaer Polytechnic Institute); accounting, finance.

Triscari, T.—Ph.D. (Rensselaer Polytechnic Institute); information systems.

Assistant Professors

Berkley, R.—Ph.D. (University of Wisconsin-Madison); organizational behavior, human resource management.

Corbett, A.—Ph.D. (University of Colorado, Boulder); entrepreneurship.

Golden, T.—Ph.D. (University of Connecticut); organizational behavior, human resource management.

Hollingworth, D.—Ph.D. (University of Minnesota); operations management.

Jahng, J.J.—Ph.D. (University of Wisconsin at Milwaukee); information systems.

Jayanthi, S.—Ph.D. (University of Minnesota); manufacturing operations, operations management.

Linton, J.—Ph.D. (York University); operations management.

Nambisan, S.—Ph.D. (Syracuse University); information systems.

Nelson, M.—Ph.D. (University at Albany, SUNY); information systems.

O’Connor, G.—Ph.D. (New York University); marketing, product management.

Young, N.—Ph.D. (University of Chicago); entrepreneurship.

Research Assistant Professors

Mehta, S.—Ph.D. (University of Texas Southwestern Medical Center); biotechnology.

Clinical Assistant Professors

Dickinson, L.B.—Ph.D. (Rensselaer Polytechnic Institute); management information systems.

Morgan, I.W.—MBA (University of Chicago); finance.

Murtagh, J.P., Jr.—Ph.D. (Rensselaer Polytechnic Institute); investment analysis and financial services.

Robbins, R.W.—M.S. (Binghamton University); accounting, information systems implementation.

Sands, R.—M.S., MBA (University at Albany, SUNY); organizational behavior and human resource management.

Adjunct Faculty

Alben, R.—Ph.D. (Harvard University); physics, operations management.

Johnson, H.—A.B. (Dartmouth College); financial markets and analysis.

Nealon, W.—MBA (Rensselaer Polytechnic Institute); accounting.

Nugent, P.—Ph.D. (University at Albany, SUNY); organization theory.

Russell, S.—Ph.D. (The Fielding Institute); human organizational systems.
Wright, F. —M.S.E.E. (Naval Postgraduate School); general management, manufacturing operations, international business.

Hartford Campus Faculty
Clinical Professors
Bragaw, L.K., Jr. —D.B.A. (George Washington University); policy and strategy, ethical and social issues.
Emiliani, M.L. —Ph.D. (Brown University); supply networks, lean business management, technology management, operations.
Kelly, L.J. —Ph.D. (University of Connecticut); statistics, operations, management engineering.
LaPlaca, P.J. —Ph.D. (Rensselaer Polytechnic Institute); marketing.
Luddy, W.J., Jr. —J.D. (University of Connecticut); ethics, social and legal issues, policy and strategy.
Schroth, P.W. —S.J.D. (University of Michigan); international finance, financial markets.
Slangen, G.H. —Ed.D. (University of Massachusetts); human resources.

Clinical Associate Professors
Albright, R.R. —Ph.D. (University of Pittsburgh); strategy.
Fransson, M.C. —MBA (Dartmouth College); marketing, financial services.
Gingerella, L.W., Jr. —MBA (Rensselaer Polytechnic Institute); accounting, finance.
Grasso, L.P. —Ph.D. (Boston University); accounting, finance.
Jenkins, F.C. —MBA (University of Pennsylvania); finance, acquisitions and mergers.
Klein, H.E. —D.B.A. (University of Kentucky); accounting, finance.
Maleyeff, J. —Ph.D. (University of Massachusetts); statistics, operations, management engineering.
Olson, P.W. —Ph.D. (Columbia University); international marketing.
Rainey, D.L. —Ph.D. (Rensselaer Polytechnic Institute); environmental management, operations, technology management, new product development.
Stodder, J.P. —Ph.D. (Yale University); economics, international.

Clinical Assistant Professors
Arnheiter, E.D. —Ph.D. (University of Massachusetts); manufacturing, operations, quality management.
Chase, R. —Ph.D. (University of Southern California); marketing, promotion strategy.
Ilovici, I. —Ph.D. (University of Connecticut); management information systems.
Peteros, R.G. —J.D. (Visiting) (Western New England College School of Law); finance.

Course Descriptions
Courses directly related to all Management curricula are described in the Course Description section of this catalog under the department code MGMT.
Table of Contents

Degrees Offered and Associated Departments 324
Overview of Undergraduate Educational Programs 324
Overview of Graduate Educational Programs 328
Biology 329
Chemistry 336
Computer Science 346
Earth and Environmental Sciences 356
Mathematical Sciences 363
Physics, Applied Physics, and Astronomy 374
Computer Science at Hartford 382
Interdisciplinary Programs and Research 385
  Applied Science 385
  Biochemistry and Biophysics 386
  Bioinformatics and Molecular Biology 390
  Center for Terahertz Research 393
  Environmental Science 394
  Interdisciplinary Science 398
  Multidisciplinary Science 400
  The Darrin Fresh Water Institute 401
  New York Center for Studies on the Origins of Life 402
  New York State Center for Polymer Synthesis 404
School of Science

Dean: Joseph E. Flaherty

Associate Dean: Samuel C. Wait Jr.

Institute Professors: Ivar Giaever, E. Bruce Watson

School of Science Home Page: http://www.science.rpi.edu

The realm of science is a constantly growing and expanding field. Today, more and faster than ever before, new and exciting discoveries are augmenting human knowledge of this world and the vast reaches beyond it. As always, Rensselaer faculty and graduates are leading the way in making many of these important discoveries.

Science and mathematics have been at the heart of Rensselaer since its founding, and most important to maintaining this tradition has been the Institute’s commitment to anticipating and generating advancements in all aspects of these fields. In the 1960s, for instance, the School of Science incorporated the then new field of computer science, eventually developing it into a distinct department.

Today, Rensselaer prepares students for a wide variety of careers in the firmly established areas of mathematics and the natural sciences while forging ahead to develop excellent new programs in the emerging field of information science. New curricula in bioinformatics and molecular biology and information technology are meeting the high demand for scientists in these areas. A new biotechnology and interdisciplinary research building will accommodate additional research in these new fields, as will Rensselaer’s dedication to attracting leaders in this field to its faculty.

Indeed, the School of Science faculty consists of some of the world’s most highly educated and accomplished scientists. Included among them are a Nobel laureate and three National Academy members. In addition, many are fellows in their professional societies, and all have achieved the highest attainable degree in their fields.

At Rensselaer, this esteemed faculty works closely with undergraduates through both instructional and research programs. Rensselaer has a long-standing commitment to undergraduate teaching, and Institute professors have authored some of the most widely used science and mathematics textbooks.

At the graduate level, Rensselaer’s School of Science offers opportunities to conduct research in a wide range of areas. These include applied mathematics; astrophysics; biophysics; the chemistry and physics of electronic, optical, and structural materials; bioorganic and biophysical chemistry; environmental science; earth science; mathematical modeling; parallel computation; networking; pervasive computing, computer imaging, and vision; scientific computation; and data science.

Enhancing these research opportunities are the many Rensselaer facilities that expose students to highly advanced equipment and technology. Among the Institute’s state-of-the-art computational and laboratory equipment are parallel computers for high speed computation, experimental computer network facilities, an electron microprobe for surface analysis, and molecular beam epitaxy for growing innovative electronic and optical materials, and automated X-ray facilities for studying the structure of crystals. Also impressive are Rensselaer’s terahertz imaging capabilities and computer vision and robotics laboratories.

The research activities of many School of Science faculty members are conducted within the Institute’s major interdisciplinary research centers, including the Center for Integrated Electronics (CIE), the Nanotechnology Center, the Scientific Computation Research Center (SCOREC) and the Terahertz Research Center.
Also providing unique opportunities to its students are a number of School of Science administered research centers. These are the David M. Darrin ’40 Fresh Water Institute, the New York State Center for Polymer Synthesis, the New York State Center for Studies on the Origins of Life, the Rensselaer-Wadsworth Center for Bioinformatics, and the Center for Biophysics. These centers engage graduate and undergraduate students alike in leading-edge research activities.

These centers complement the programs offered through the six departments within the School of Sciences. These departments are Biology, Chemistry, Computer Science, Earth and Environmental Science, Mathematical Sciences, and Physics, Applied Physics, and Astronomy. Additionally, the school administers the interdisciplinary Information Technology Program and offers a full complement of interdisciplinary degree programs that are described in detail under the School of Science Interdisciplinary Programs and Research section of this catalog.

### Degrees Offered and Associated Departments

<table>
<thead>
<tr>
<th>Degree</th>
<th>Associated Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy</td>
<td>Physics, Applied Physics, and Astronomy</td>
</tr>
<tr>
<td>Applied Science</td>
<td>Administered by Dean of Science</td>
</tr>
<tr>
<td>Biology</td>
<td>Biology</td>
</tr>
<tr>
<td>Biochemistry/Biophysics</td>
<td>Biology/Chemistry</td>
</tr>
<tr>
<td>Bioinformatics and Molecular Biology</td>
<td>Biology/Chemistry/Computer Science and Mathematical Sciences</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Chemistry</td>
</tr>
<tr>
<td>Computer Science</td>
<td>Computer Science</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>Earth and Environmental Sciences</td>
</tr>
<tr>
<td>Geology</td>
<td>Earth and Environmental Sciences</td>
</tr>
<tr>
<td>Hydrogeology</td>
<td>Earth and Environmental Sciences</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Mathematical Sciences</td>
</tr>
<tr>
<td>Applied Mathematics</td>
<td>Mathematical Sciences</td>
</tr>
<tr>
<td>Multidisciplinary Science</td>
<td>Administered by Dean of Science</td>
</tr>
<tr>
<td>Natural Sciences</td>
<td>Center for Innovation in Pre-College Education</td>
</tr>
<tr>
<td>Physics</td>
<td>Physics, Applied Physics, and Astronomy</td>
</tr>
<tr>
<td>Applied Physics</td>
<td>Physics, Applied Physics, and Astronomy</td>
</tr>
<tr>
<td>Interdisciplinary Science</td>
<td>Administered by Dean of Science</td>
</tr>
</tbody>
</table>

### Overview of Undergraduate Programs

The School of Science prepares students for a broad range of careers in natural science, computer science, and mathematics, as well as in such diverse areas as management, technological communication, and industry or government agencies, or for graduate studies that may include medical, dental, or law school. The school’s educational goals for all of these students, however, are to give them:

- A broad background in their particular field
- Working knowledge of modern research and technological tools
- An appreciation of good theoretical, experimental, and computational research
- Preparation for a lifetime of learning and discovery as both individuals and part of a team.
Students may attain these goals through a variety of majors offered within the six School of Science departments or through interdisciplinary degree programs offered in biochemistry/biophysics, bioinformatics and molecular biology, and environmental science. A major in interdisciplinary science is also available to students wishing more breadth in their program. Additionally, the Information Technology (IT) degree program offers another unique option. The IT core program is coupled with eight courses in another application area that may be chosen from any of the mathematics or science disciplines, as well as other campus programs. For more details on this program see the Information Technology section of this catalog.

All programs offer a large number of electives so that students can emphasize their areas of interest, select one or more minors, or study a wide range of topics in addition to obtaining a strong background in their major field of study.

Selection of a major within the School of Science may take place at any time during the first year of study or during the admissions process. Students who are undecided may defer their choice of major until the sophomore year. With the exception of programs requiring joint admission outside the School of Science, the choice of any approved curriculum within the school is guaranteed. Entering students who have not yet selected a major may choose the department from which their initial adviser is selected.

Advanced placement credit or credit for courses taken in the International Baccalaureate program is possible in those areas where examinations are given. Transfer students are welcome; formalized agreements exist with several community colleges so that students who have followed specified curricula in the community college will have all the standard freshman and sophomore requirements of the science departments at Rensselaer. Students transferring from other colleges will receive credit depending on the courses taken.

Core Program in Science
All Institute undergraduate students are required to complete a core program in science. As part of this program, students must take a minimum of 24 credit hours in physical, life, and engineering sciences, including at least eight credit hours of mathematics. No more than one course of the science core may be taken as Pass/No Credit.

To ensure that students have some depth in their science core, they must take at least two courses within a single area other than mathematics. For this purpose, the course codes MATH (mathematics) and MATP (mathematical programming, probability, and mathematical statistics) are a single discipline. Any of the courses with the following course codes meet the physical, life, and engineering sciences requirement: ASTR, BCBP, BIOL, CHEM, CISH, CSCI, ERTH, MATH, MATP, PHYS. In addition, the following courses also meet these requirements:

- IENV-4500 (cross-listed as ERTH-4500)
- IENV-4700
- ISCI-4500
- ENGR-1100 (as Science not Mathematics)
- ENGR-1600
- ENGR-2090
- ENGR-2250
- ENGR-2830
- ESCE-2100

Other courses may fulfill this requirement and will be reviewed by the associate dean of science on a case-by-case basis. A number of upper-level courses in several engineering disciplines would satisfy the requirement, but generally they have enough prerequisites that the science requirement would already have been satisfied.
Transferring Credit Towards the Science Core

Students entering Rensselaer as first-year students may transfer up to two science courses (up to eight credit hours) toward satisfying their science core requirement.

Students who have advanced placement or who have the International Baccalaureate may be granted credit for all such mathematics and science courses depending on their scores.

Transfer students from an accredited collegiate program who have completed at least one college year but who come to Rensselaer with first year status may qualify for additional core transfers at the discretion of the science core curriculum adviser (currently the associate dean of the School of Science). Transfer students entering Rensselaer at the junior level or above are not limited in the number of courses they may transfer for science core credit.

Students enrolled at Rensselaer who wish to take a science course for core credit or other science credit at another accredited institution must obtain prior approval for the course from the science core curriculum adviser. To apply for approval, a student must furnish a catalog description of the proposed course and a completed copy of Rensselaer’s transfer credit approval form to the Science core curriculum adviser. A maximum of eight credit hours of transfers is allowed towards the 24-credit-hour science core.

Baccalaureate Programs

Students entering as freshmen may pursue Bachelor of Science degrees in applied physics, bioinformatics and molecular biology, biology, biophysics/biochemistry, chemistry, computer science, environmental science, geology, hydrogeology, interdisciplinary science, mathematics, and physics. A bachelor’s program that combines Information Technology with a concentration in mathematics or science is also available.

Additional options are available in astronomy, biochemistry, biophysics, computing in chemistry, engineering chemistry, geophysics, operations research, polymer science, mathematics of computation, and many others. In these options, students choose courses from a list to make a coherent program of several courses in the same area.

A B.S. in any of these curricula requires between 124 and 128 credit hours. No Bachelor of Science curriculum requires more than 72 credit hours of science courses. In addition, no more than 76 credit hours will consist of required courses, or courses to be chosen from a list of named electives. A maximum of 40 credit hours may be specified under a single discipline such as PHYS or BIOL.

A minimum of 46 credit hours in science is required for a B.S. degree. Eight of these credit hours must be in mathematics (course codes MATH and MATP), including Calculus I. Each curriculum must include courses in at least four science disciplines. For this purpose, the course codes MATH (mathematics) and MATP (mathematical programming, probability, and mathematical statistics) are a single discipline.

Each curriculum also offers an option that allows a student to receive up to four hours of course credit for an out-of-classroom experience. Students may exercise this option more than once. This out-of-classroom experience should have intellectual content relevant to the student’s educational or career goals. Appropriate experience might include an individual or group research project (on or off campus), an independent study project, a cooperative education assignment, a public service internship, or study abroad. A written proposal and a final written report must be submitted for evaluation to the faculty member designated by each curriculum. This course option may be included in the courses required for the major.

Additional opportunities for undergraduate science students are dual majors and minors. Flexible curricula make dual majors possible between all science majors. In addition, School of Science students may also arrange a dual major in science and humanities or social science or science and management. While the more structured architecture and engineering curricula make dual majors in these areas more diffi-
cult, students with advanced placement or advanced standing may be able to satisfy the requirements for dual degrees in these areas.

Students also frequently take minors in one of the science programs or in other Institute programs ranging from philosophy to management to engineering. Minor programs are available in each of the sciences and mathematics, as well as in environmental science and biochemistry/biophysics. Consult the individual department or program descriptions for details of minor programs.

**Special Undergraduate Opportunities**

**Accelerated Programs**
The School of Science offers an accelerated physician-scientist program in cooperation with Albany Medical College. Accelerated programs leading to M.S. or Ph.D. degrees are also possible in some areas. Consult departmental descriptions for details.

Through the Lally School of Management and Technology, a student can also obtain an MBA in five years in addition to a B.S. in science. While the MBA normally requires 60 credits, students opting for this program take four recommended electives as undergraduates and thereby reduce that requirement to 48 credit hours. Admission to the accelerated B.S./MBA program is highly selective and limited to a small number of outstanding applicants who meet Rensselaer’s admission requirements and the requirements of the Lally School of Management and Technology graduate program.

**Undergraduate Research Experience**
At Rensselaer, involving undergraduates in real-world research is of paramount importance. Through the Undergraduate Research Program (URP), described in the Educational Programs and Resources section of this catalog, undergraduates work directly with faculty and/or graduate students on projects requiring critical inquiries. These studies involve exciting areas of leading-edge technological research and have the potential to result in groundbreaking discoveries. Involvement in URPs can be arranged strictly for the experience, for credit, or for pay. Students apply through direct contact with faculty seeking students via Web site or campus advertisements.

**Cooperative Education**
Students may augment their academic course work with on-the-job experience through the Cooperative Education program. Studies and work assignments are scheduled after consultation with their curriculum adviser. Although many co-op students complete their academic program in four years, some delay graduation for a year to obtain additional work experience. Additional information on Rensselaer’s cooperative education programs can be found in the Student Life section of this catalog under the Career Development Center heading.

**Study Abroad/Exchange Programs**
Although the School of Science does not specifically administer any such programs, the Institute offers a number of study abroad/exchange programs that are open to the student body as a whole. For more information on these Institutewide programs, see the Educational Programs and Resources section of this catalog.
Overview of Graduate Programs

Rensselaer’s greatest strength—the interface between science and engineering—is a unique feature that particularly benefits graduate students by providing a wide and unique variety of research areas. Graduate students are also key to the Institute’s ability to remain in the forefront of research and education in the sciences and to apply its research findings to needs of society.

Considerable personal attention is focused upon graduate students as they enter and develop their programs of study. A graduate adviser guides each student by assisting in the establishment of a suitable program to meet particular needs of that individual. Courses may be pursued for special purposes, as well as be applied to programs leading to a Master of Science or a Doctor of Philosophy degree.

Recognizing that the divisions between basic science disciplines and specializations within particular sciences are not as distinct as they once were, the School has developed many interdisciplinary programs. These programs allow for greater flexibility and situations in which research in one area may serve advanced degree requirements in another. This is especially evident in such areas as applied mathematics with an emphasis on modeling and analysis. Other examples include bioinformatics that spans biology, chemistry, computer science, and mathematics; materials science stressing electronic, optical, polymeric, and structural materials in the New York Center for Polymer Synthesis; environmental research in the David M. Darrin ’40 Fresh Water Institute; the New York Center for Studies on the Origins of Life; the focus on advanced computation in the areas of software, databases, and parallel computation; and the Center for Biophysics foci on natural processes as well as bio-organic chemistry, pharmaceuticals, and biotechnology.

Many science students and faculty also participate in Institute-wide research activities including composite materials, integrated electronics, design, manufacturing productivity, robotics, etc. Still others participate in co-op programs with industry. For more details on graduate cooperative education opportunities, contact the Career Development Center.

Numerous School of Science graduate students hold teaching assistantships, research assistantships, and fellowships while pursuing their degrees. Upon leaving Rensselaer with an advanced degree in mathematics or science, these individuals easily find positions with corporations and government facilities or obtain postdoctoral and faculty positions at the most prestigious universities.

Master’s Programs

The School of Science offers Master of Science (M.S.) degrees in applied science and in multidisciplinary science. For more information and specific details on these degree programs, see the Interdisciplinary Programs and Research section within the School of Science section of this catalog. In addition, all of the School’s individual departments offer master’s programs.

Doctoral Programs

Each School of Science department offers programs of doctoral study, and the Ph.D. is awarded in biology, chemistry, computer science, geology, mathematics and physics. Additional doctoral degree options are also available in a variety of special programs including astrophysics, surface science, mathematical programming, operations research, polymer science, and multidisciplinary science. These programs, particularly the program in multidisciplinary science, are a testament to Rensselaer’s commitment to encouraging study programs that cross disciplines within departments and even Institute schools. Detailed information on such programs follow within the School of Science Interdisciplinary Programs and Research section of this catalog.
Biology

Chair: Robert E. Palazzo
Associate Chair: Robert Parsons
Accelerated Program Head: M.H. Hanna
Graduate Admissions Coordinator: Joelle Willis
Department Home Page: http://www.rpi.edu/dept/bio/info/bio.html

For two decades, the science of biology has been undergoing revolutionary change. Many problems once handled only descriptively are now analyzed molecularly, and biological systems are now characterized in molecular terms. With this trend expected to continue into future advances in biology, Rensselaer is adapting and introducing undergraduate and graduate biology programs to meet this challenge.

All areas of biology require knowledge of chemistry and physics as well. The undergraduate biology curriculum, therefore, thoroughly trains students in the fundamentals of the life sciences and the chemistry and physics of the life processes, providing the background necessary for professional training in research or medicine. Options are available to prepare students for careers in applied biology and in industry. Programs of study in biology may also be combined with specific options in biochemistry, biomedical engineering, bioinformatics, biophysics, biotechnology (genetic engineering), chemical engineering, computer science, management, mathematics, microbiology, and technical communications.

Research and Innovation Initiatives

Biochemistry and Biophysics
The study of fundamental problems in modern biochemistry and molecular biochemistry employ a variety of advanced techniques. Current work at the gene and protein levels is being applied in cell biology and physiology. Understandably, a wide range of government agencies and foundations, including the National Institutes of Health, the National Science Foundation, and the American Diabetes Association, is supporting such exciting work.

Research in this area includes developing computer models of how the lens accommodates the human eye. Studies on the lens protein alpha crystalline include biochemical and biophysical characterization. Novel molecular genetics approaches are used to compare properties of alpha crystalline to members of the small heat shock protein family. Another laboratory is researching the involvement of molecular chaperones (heat shock proteins) in the assembly of a large oligomeric enzyme.

In the area of enzymology, projects include work on the nitric oxide synthase isoforms, which are important to signal transduction (e.g., in the central nervous system and for blood pressure control) and as producers of cytotoxic NO in immune responses. Using molecular genetics and biochemical methods, nitrogen fixation and nitrogen cycle enzymes in cyanobacteria are also under investigation. Additionally, molecular modeling techniques are being used in the design of mutants of eukaryotic P450 enzymes.

Much of this research is conducted through collaboration with colleagues in other departments who are members of the Interdisciplinary Program in Biochemistry/Biophysics or the Center for Biophysics and with scientists from other universities.

Bioinformatics and Molecular Biology
Research in bioinformatics and molecular biology includes both computational work and applications using molecular genetic approaches. In the computational sphere, design and application of database
search and sequence alignment algorithms, molecular modeling, and simulation are used in studies rang-
ing from structural characterization of biomedically relevant proteins to investigations of evolutionary
adaptation in marine environment. Problems of protein folding are studied using modeling and data min-
ing from genomic and structural databases. Molecular genetic approaches are used to test the prediction
of modeling studies, to design and produce probes, and to obtain sequence information for novel genes.
Three laboratories are involved in engineering novel proteins or activities of existing proteins, using molec-
ular gene manipulations.

Microbiology and Ecology
In this program, faculty and their students are conducting ecological, molecular, and genetic studies. Both
basic and applied research projects are available, sometimes within the same laboratory. Significant col-
aboration occurs between these researchers and faculty in other areas of biology, in other Rensselaer
departments, and at other institutions around the world. Ecological studies include freshwater ecology,
biotransformation of organic compounds, and geomicrobiology. Molecular studies include work on nitro-
gen fixing symbiotic bacteria and bacteria living in the environment using recombinant DNA technolo-
gy, and overlap in some cases with genetic studies of prokaryotes and eukaryotes. A variety of graduate
courses in microbiology, molecular biology, virology, and immunology are offered. In addition, the Darrin
Fresh Water Institute at Lake George is well equipped for studies in microbial ecology.

Cell and Molecular Biology
Research in cell and molecular biology is a high priority in the Biology Department. Four research areas
are prominently featured. The first focuses on the biochemical control of cytoskeletal organization, micro-
tubule dynamics, cell polarity, and cell differentiation. The second is centered on the role of extracellular
matrix proteins and their control of normal and cancerous cell growth and migration, as well as wound
healing. The third is concerned with signal transduction mechanisms controlling cell-cell interactions
during tumor cell migration. The fourth focuses on stem cell growth and regulation in the context of tis-
sue engineering. An undergraduate laboratory course that teaches basic research techniques in these areas
is available, and students are encouraged to work in research labs upon completion of this course. The
department faculty maintains close collaborations with faculty in other departments such as Chemistry,
Biomedical Engineering, Mathematical Sciences, and Chemical Engineering.

Interdisciplinary Programs
See also Biochemistry/Biophysics, and Bioinformatics and Molecular Biology, under the Interdisciplinary
Programs and Research section beginning on page [386].

Faculty*
Professors
Boylen, C.W.—Ph.D. (University of Wisconsin); microbial ecology, physiological effects of starvation
on microorganisms.
Diwan, J.J.—Ph.D. (University of Illinois); cell physiology, bioenergetics.
Dordick, J.—Ph.D. (Massachusetts Institute of Technology); (joint appointment with Chemical
Engineering).
Koretz, J.E.—Ph.D. (University of Chicago); structural biophysics of protein aggregation, computer
modeling.
McDaniel, C.N.—Ph.D. (Wesleyan University); plant development and cell culture.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions,
including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees
meeting.
Nierzwicki-Bauer, S.A.—Ph.D. (University of New Hampshire); plant molecular biology, subsurface microbiology.

Palazzo, R.E.—Ph.D. (Wayne State University); cellular organization, cell replication, cell motility, development and cancer.

Roy, H.—Ph.D. (Johns Hopkins University); plant molecular biology and biochemistry.

Salerno, J.C.—Ph.D. (University of Pennsylvania); enzymology, spectroscopy, molecular structures, bioinformatics.

Zuker, M.—Ph.D. (Massachusetts Institute of Technology); algorithms for predicting RNA and DNA secondary structure (joint appointment with Mathematics).

Research Professors

Bedard, D.—Ph.D. (University of Chicago); environmental microbiology and ecology, microbial molecular biodegradation of halogenated aromatics.

Lister, B.—Ph.D. (Princeton University); ecology, undergraduate education (joint appointment with The Anderson Center for Innovation in Undergraduate Education).

Associate Professors

Hanna, M.H.—Ph.D. (University of Illinois); directed evolution of proteins.

Parsons, R.H.—Ph.D. (Oregon State University); cellular physiology, epithelial transport.

Assistant Professors

Bystroff, C.—Ph.D. (University of California, San Diego); genomics, protein structural prediction.

Plopper, G.—Ph.D. (Harvard); signal transduction in tumor cell biology and tissue engineering.

Xu, J.—Ph.D. (Meharry Medical College); signal transduction by extracellular matrix.

Professors Emeritus

Ehrlich, H.L.—Ph.D. (University of Wisconsin); geomicrobiology, mineral transformations by bacteria.

Pfau, C.J.—Ph.D. (Indiana University); molecular biology of animal viruses, antiviral drugs.

Associate Professor Emeritus

Clesceri, L.S.—Ph.D. (University of Wisconsin); microbial ecology, biotransformation and biodegradation of natural polymers and pesticides, biotechnology.

Clinical Assistant Professors

Crone, D.E.—Ph.D. (Duke University); molecular biology, biochemistry.

Smith, S.M.E.—Ph.D. (Rensselaer Polytechnic Institute); bioinformatics, enzyme structure.

Adjunct Faculty

Bawa, R.—Ph.D. (Rensselaer Polytechnic Institute); biotechnology, patents.


Manella, C.—Ph.D. (University of Pennsylvania); mitochondrial membrane transport.

Undergraduate Programs

Undergraduate students may pursue either a baccalaureate program or an accelerated degree program. Both of these degree programs are explained in detail below.

Baccalaureate Programs

The undergraduate curriculum in biology is designed to prepare students for admission to graduate or professional school. Recognizing that flexibility is essential for students with specific interests and goals other than those spelled out in the traditional curricula, it is designed to leave many options open to the student. The following is a sample biology curriculum, completion of which requires a minimum of 128 credit hours.
Electives
Ten courses in biology are required for graduation. Careful selection of biology electives and technical electives in the third and fourth years may contribute significantly to preparation for various professional goals. Technical electives include any pertinent courses in biology, other sciences, or mathematics.

A student who anticipates working on a senior thesis is strongly urged to take two of the advanced laboratory courses (BIOL-4710, BIOL-4720, BIOL-4740) in their junior year, since these courses offer excellent preparation for independent laboratory work.

Concentrations
Technical and free electives may be chosen to provide a concentration in biochemistry, bioinformatics, biomedical engineering, biophysics, biotechnology (genetic engineering), chemical engineering, computer science, environmental science, management, mathematics, microbiology, psychology, or technical communication. Program advisers should be consulted.

* Chosen from one of the following three courses: BIOL-4710, BIOL-4720, or BIOL-4740. All three courses are writing intensive.

** One of the biology electives can be chosen from any of the following classes: All BCBP except BCBP-4760, CHEM-2440, CHEM-4300, or CHEM-4330.
Minor Programs
The Biology Department offers minors in biochemistry, biophysics, astrobiology and biology. The biochemistry minor is designed specifically for biology or bioinformatics majors and the biophysics minor is designed specifically for students majoring in biology. The requirements for all department minors are given below.

Minor Programs
Astrobiology
To complete this minor, students must take a minimum of 16 credits of course work in this field. These courses include ASTR-4510 and ISCI-4500, four credits each, and two semesters of the one-credit course ISCI-4510. Two additional courses outside the major field of study must be selected from the following:

- ENVE-2110 Intro. to Environmental Engineering
- BIOL-4320 Geomicrobiology
- BIOL-4440 Microbial Ecology
- BIOL-4620 Molecular Biology
- BIOL-4760 Molecular Biochemistry I
- BCBP-4810 Biological Spectroscopy
- BCBP-4860 Protein and Nucleic Acid Structure

The requirement that the two selected courses must be outside the major field of study is reduced to one in the case of a double major, provided both majors are in primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Biochemistry
To complete this minor, a biology major must take BCBP-4770, CHEM-2440, and two of the following courses:

- BIOL-4260 Cell Biology  BCBP-4860 Protein and Nucleic Acid Structure
- BCBP-4710 Biochemistry Laboratory  CHEM-4310 Bioorganic Mechanisms
- BCBP-4310 Genetic Engineering  BCBP-4780 Protein Folding

Biophysics
To complete this minor, a biology major must take BCBP-4770, CHEM-2440, and two of the following courses:

- MATH-2400 Differential Equations  BCBP-4210 Biophysical Methods
- MATH-4720 Mathematics in Medicine and Biology  BCBP-4810 Biological Spectroscopy
- BIOL-4270 Human Physiology I  PHYS-2510 Quantum Physics
  
  (requires MATH-2400)

Biology
Students not majoring in biology may receive a minor in this discipline by taking eight credits of introductory biology. These credits must include BIOL-2120 and either BIOL-2310 or BIOL-1010. Also included are BIOL-2500 and three 4000-level courses of the student’s choice.

Accelerated Program
The Biology Department offers highly motivated students interested in the medical profession the opportunity to combine undergraduate and graduate study to reduce the number of years spent in academic study. The program is described below.

Physician-Scientist Program
This accelerated biomedical program leads to the B.S. degree from Rensselaer and the M.D. degree from Albany Medical College (AMC). Through this program, both degrees can be obtained within seven calen-
Many years, including some summers.

Admission to the biomedical program is limited to individuals who have not yet initiated full-time undergraduate study and who display the motivation, maturity, and intellectual capacity necessary to pursue this accelerated course of study. Rensselaer conducts initial reviews and then forwards applications of candidates meeting the Institute’s program standards to Albany Medical College for further review. Only those applicants with uniformly superior academic credentials and the highest test scores are invited to the required interview at Albany Medical College. Some experience or demonstrated interest in biological or biomedical research during high school is considered as a factor in admission. The interview process assesses the applicant’s motivation for medicine, level of maturity, and level of personal development.

The biomedical program seeks and admits students without discrimination based on race, religion, color, gender, age, or handicap as defined in the Rehabilitation Act of 1973, or national or ethnic origin. Ordinarily, admission to the program is limited to citizens of the United States. Candidates must complete secondary school with superior scholastic credentials. Course work must include four years of English, one year each of physics, chemistry, and biology, and mathematics through precalculus. The Scholastic Aptitude Test (SAT) I or ACT examination and SAT II in mathematics (Level I, Level IC, Level II, or Level IIC), writing, and physics, biology, or chemistry are required, and must be completed by the November testing date prior to the proposed September matriculation in the program. Scores of tests taken thereafter will not be considered. Preferably, secondary school applicants will have taken these tests in the spring preceding application. Applications must be filed and completed prior to December 1, which is earlier than application for normal admission.

Provided that the student maintains satisfactory standards of academic achievement, admission leads automatically to entrance into Albany Medical College after three years of study at Rensselaer (six semesters). A minimum grade point average of 3.40 (overall GPA and science/math GPA) is required each semester at Rensselaer. At the completion of the third fall semester, a minimum grade point average of 3.40 is required both in overall course work and in science/math for promotion to the medical portion of the curriculum. All course work at Rensselaer must be satisfactorily completed before beginning the fourth year of study at Albany Medical College. A grade of D or F in any science course generally requires immediate transfer out of this program. Grades of I (Incomplete) are not accepted without justification involving illness or specific course structure. When an Incomplete is granted, the course work must be completed no later than one month after the last day of the examination period of the semester in which the incomplete was received.

Promotion to the medical portion of the curriculum is based not only on academic achievement, but also on the fitness of the student to enter the profession of medicine. Students may transfer into Rensselaer’s regular four-year undergraduate program at any time during the premedical portion of the biomedical program. The three years of Rensselaer study include a sound basis in the physical sciences, an introduction to the major concepts and principles of biology and biological research, and ample opportunity to become acquainted with the humanities and social sciences. Students in the biomedical program will take 24 courses at Rensselaer over the three years. During the third summer (the transition between Rensselaer and Albany Medical College), students continue with research projects begun while at Rensselaer. These research projects will be completed during the fourth summer while at Albany Medical College. Students should plan on spending eight weeks of full time study during the summers. Biology course credit will be given for the two courses taken during the third summer and five additional preclinical courses taken at Albany Medical College to complete the undergraduate requirements for the B.S. degree.

Since many biomedical students will enter Rensselaer with advanced placement credit, a large proportion will have undergraduate course work credit in excess of standard requirements. These advanced placement credits will allow them to take advanced or additional course work, but cannot be used to decrease the length of time allotted to their undergraduate experience or to decrease the number of courses prescribed in the curriculum. All courses specifically named in the curriculum must be taken at Rensselaer, or given AP credit, or
transferred in from courses taken prior to admission at Rensselaer. After completing the fourth year of the program, students receive a B.S. degree from Rensselaer. The M.D. degree is received at the end of the seventh year and is dependent upon completing all requirements for the B.S. degree. Requests for further information and applications for admission to this program should be addressed to the Office of Undergraduate Admissions, Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York 12180-3590.

**Seven-year Accelerated Physician-Scientist Program**

**Academic Year I**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1100 Chemistry</td>
<td>4</td>
<td>BIOL-2120 Intro. to Cell and Molec. Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-1010 Intro. to Biology</td>
<td>4</td>
<td>CHEM-1200 Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Academic Year II**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1100 Physics I</td>
<td>4</td>
<td>PHYS-1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-2250 Organic Chemistry I</td>
<td>4</td>
<td>BIOL-4620 Organic Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-2500 Genetics and Evolution</td>
<td>4</td>
<td>CHEM-2260 Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1100 Chemistry</td>
<td>4</td>
<td>BIOL-2120 Intro. to Cell and Molec. Biology</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-1010 Intro. to Biology</td>
<td>4</td>
<td>CHEM-1200 Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Academic Year III**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-4760 Molecular Biochemistry I</td>
<td>4</td>
<td>BIOL-4290 Human Physiological Systems</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-2410 Embryology</td>
<td>4</td>
<td>BIOL-xxxx1 Research Methodology</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
<td>BIOL-2980 Biomedical Research</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Summer Session at Albany Medical College**

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammalian Anatomy</td>
</tr>
<tr>
<td>Research Methods</td>
</tr>
</tbody>
</table>

**Academic Years IV–VII (at Albany Medical College)**

The following courses are transferred from the Albany Medical College

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mammalian Anatomy</td>
</tr>
<tr>
<td>Research Methods</td>
</tr>
<tr>
<td>Musculoskeletal System</td>
</tr>
<tr>
<td>Nervous System</td>
</tr>
<tr>
<td>Cardiovascular System</td>
</tr>
<tr>
<td>Gastrointestinal System</td>
</tr>
<tr>
<td>Endocrine System/Metabolism</td>
</tr>
<tr>
<td>Total credits transferred from Albany Medical College</td>
</tr>
</tbody>
</table>

1 The number for this course has not yet been determined.
Graduate Programs

The biology research laboratories at Rensselaer are equipped for graduate study and projects in cell and molecular biology, biochemistry, bioinformatics, biophysics, microbiology and microbial ecology, recombinant DNA and genetics, and vision regulation. In addition, cooperative programs with other organizations provide a wider range of research possibilities. Rensselaer's Darrin Fresh Water Institute at Lake George offers a program on lake ecosystem analysis involving field, laboratory, and computer analysis of biological, chemical, and physical data. An active program in biochemistry and biophysics is jointly sponsored with the Chemistry, Physics, Mathematics, and Chemical Engineering Departments. Students must complete a core curriculum that includes courses in general biochemistry and molecular biology and pass a qualifying exam. Qualified students may take a candidacy examination in their special area of interest and proceed to the Ph.D. under the guidance of the candidacy committee. Other students seeking an M.S. degree must complete a thesis based on original research. Students work toward M.S. and Ph.D. degrees in biology. The detailed curriculum is tailored to the student's background and special interests.

Master’s Programs

Thirty credit hours of course work are necessary to complete the M.S. program. A minimum of six credits and a maximum of nine must be in research. Of the remaining credits, 15 must be in graduate-level courses. A thesis based on an original research project is required.

Doctoral Programs

Candidates for the Ph.D. must satisfy the requirements of the graduate evaluation committee (GEC), pass the qualifying exam, and pass a candidacy exam. The latter consists of a written and an oral portion, and should usually be taken between the second and the third year of full-time study. A degree candidate also must submit a dissertation based on an original research project. The GEC requires a high level of performance in selected courses and research, and reports its findings during the second full year of full-time study. Additionally, all doctoral candidates are required to participate in teaching for one academic year under the supervision of a faculty member. The student thus gains experience teaching should he or she select an academic career. Sixty credit hours past the M.S. degree are required.

Course Descriptions

Courses directly related to all Biology curricula are described in the Course Description section of this catalog under the department code BIOL.

Chemistry

Chair: Ronald A. Bailey (Acting)

Associate Chair: Ronald A. Bailey

Undergraduate Advising: Charles W. Gillies

Graduate Admissions: James A. Moore

Department Home Page: http://www.rpi.edu/dept/chem/index.html

The Chemistry Department provides courses and programs of study that reflect the central role of chemistry in the science and technology of tomorrow. In addition to a strong focus in the traditional areas of chemistry, such as synthesis, molecular structure, and chemical reactions, the department offers courses and research programs in the rapidly developing frontiers of modern science. These areas include bio-
chemistry and biophysics, materials and polymer chemistry, and medicinal chemistry. The department offers programs leading to the B.S., M.S. and Ph.D. degrees in chemistry, as well as a minor in chemistry. Chemistry instruction is delivered in the recently renovated Walker Laboratory, which houses state-of-the-art classrooms and laboratories, and in Cogswell Laboratory, the site of the majority of the department's research activities. Undergraduate laboratories are equipped with modern computer-controlled instruments and provide students with hands-on experience with equipment similar to that found in industrial and research laboratories. Chemistry research laboratories are found in four buildings: the Cogswell Laboratory, the Materials Research Center, the recently constructed New York State Center for Polymer Synthesis, and the nearby Science Center.

Research Innovations and Initiatives

Analytical Chemistry
Areas of research include the development and application of methods to study in vivo processes, particularly the advancement of microdialysis technology. Membrane devices that facilitate mass transport using cyclodextrins are being developed for in vivo analysis. Methods of monitoring biochemical reactions at the site of the biomaterials are also of interest. Techniques such as high field and solid state NMR, FTIR, GC-MS, LC-MS and MALDI-TOF mass spectrometry are used in developing analytical procedures to detect, quantitatively determine, and structurally characterize materials in a variety of areas.

Biochemistry and Biophysical Chemistry
Pathways on the primitive earth for the origin of RNA are under investigation as part of the activities of the New York Center for Studies on the Origins of Life. The goal of this research is to determine if the RNA formed by proposed prebiotic pathways has catalytic activity, a requisite for the first life on earth. Photosynthetic electron transport and biological energy transduction mechanisms are studied by electron spin resonance and time-resolved optical and electroabsorption spectroscopies. Biochemical and biophysical research also focuses on the mechanisms of protein folding and aggregation, protein folding defects related to human diseases, and the molecular structures of proteins. The methodologies used include kinetic and spectroscopic analysis (NMR, fluorescence, circular dichroism, FTIR) of protein conformational changes, molecular modeling, computational graphics, and molecular mechanics calculations on peptides and proteins. New methods for the separation of biopolymers are being developed. A new initiative in protein chemistry is centered on the computer design and organic synthesis of proteins with novel functionalities and nonnatural architectures. The research will provide new capabilities to design purpose-specific proteins such as synthetic enzymes and artificial membrane protein receptors.

Inorganic Chemistry and Solid-State Chemistry
Inorganic chemistry involves the preparation and investigation of substances ranging from coordination complexes and organometallic compounds to inorganic solids with extended network structures. Materials and solid-state chemistry focuses on the application of both inorganic and organic substances as structural, optical, and electronic materials, and include theoretical studies on the defect structures of inorganic solids. Syntheses of organometallic compounds and inorganic polymers provide sources of novel solid-state materials, both as molecular solids and as precursors for the pyrolytic preparation of inorganic solids, such as aluminum nitride and silicon carbide.

Organic Chemistry and Organometallic Chemistry
Active areas of synthetic organic and medicinal chemistry research include the design and synthesis of novel agents to treat cocaine addiction. Research in the areas of transition organometallic chemistry and
homogeneous catalysis focuses on synthetic and mechanistic studies of organometallic complexes applicable to the conversion of carbon monoxide and carbon dioxide into organic molecules. The development of molecular modeling programs that evaluate intermolecular electrostatics may result in the deeper understanding of enzyme-substrate interactions.

**Photochemistry**
Mechanistic and synthetic photochemistry are areas of major emphasis. Investigations involve the photochemical transformations of heterocycles, carbonyl containing compounds, and naturally occurring materials. The atmospheric chemistry of Jupiter and Titan (Saturn’s largest moon), and the role of photochemical reactions in the origins of life also are under investigation. Photosynthesis and rearrangement of heterocyclic purines and photochemical reactions of possible prebiotic gases are being studied to elucidate the role of photochemistry in transformations that led to biological molecules on the primitive earth. Photochemical processes used for the generation of polymer thin films, for the photoimaging of lithographic resists, and for novel polymerization processes are also being developed.

**Polymer Chemistry and Materials Chemistry**
Synthetic and development efforts are under way in the field of high-performance thermally stable polymers, conductive polymers, liquid crystalline polymers, block copolymers, and photosensitive thermosets and thermoplastics. Novel synthetic and biorenewable monomers and methods for their synthesis are being studied. New approaches to polymer preparation, including photochemical, photo-electroinitiated, transition metal catalyzed, and vapor-deposition polymerization are also under study. Development of biologically compatible polymers that can serve as scaffolding for tissue regeneration is an area of recent interest. Polymers are characterized by means of gel permeation chromatography, viscometry, differential scanning calorimetry, scanning and transmission electron microscopy, atomic force microscopy, low-angle light, X-ray, and neutron scattering and mass spectrometry (MALDI TOF and ESI). Surface interactions between immiscible crystallizable polymers are being studied using X-ray photoelectron spectroscopy, polarized light microscopy, electron microprobe methods, and Raman spectroscopy. Properties of multiphase polymer alloys and solutions are being investigated in shear, electric, and magnetic fields. Polymerization processes are being investigated from the aspect of mechanistic organic chemistry. Polymer gels that may function as artificial muscles are also being investigated. Coordination complexes and organometallic compounds are being considered as inorganic polymers and as precursors for the pyrolytic preparation of inorganic solid-state materials.

**Surface Science**
Topics of current research interest include the study of surface interfacial tensions of liquids and liquid-liquid systems with and without surface-active solutes present. Molecular structure and orientation of liquid and solid surfaces and surface films are being studied through state-of-the-art laser spectrographic techniques. Structure and composition of films with environmental importance on lake and ocean surfaces are also under investigation by direct and remote sensing methods.

**Computational Chemistry and Spectroscopy**
Computational chemistry and molecular modeling are being developed and used to understand the relationships between molecular structures and their properties. Specialized electron density reconstruction methods, such as the Transferable Atom Equivalent (TAE) technique, have permitted the construction of predictive models that allow good estimates of the properties of new compounds to be synthesized, as well as predicting the behavior of protein displacers in the biotechnological chromatography of fermentation products. These techniques have been developed as part of the NSF Project DDASSL, together with novel machine learning and drug delivery modeling algorithms. Other theoretical chemistry projects under way emphasize understanding nonlinear optical properties of polymers, as well as predicting
the behavior of polymer displacers in the biotechnological chromatography of fermentation products. Spectroscopic research is directed particularly toward structure and properties problems of a wide range of compounds, with emphasis on vibrational (infrared and Raman), linear and nonlinear laser and microwave spectroscopy, NMR spectroscopy, electronic spectroscopy, and X-ray diffraction. Pulsed-beam Fourier-transform microwave spectroscopy is used to study van der Waals complexes and transient chemical species, with an emphasis upon understanding the mechanisms of simple chemical reactions. Solid-state NMR spectroscopy is used extensively in materials and polymer chemistry research, and in the characterization of catalysts.

Research Facilities and Equipment
Department research facilities include Cogswell Laboratory, the New York State Center for Polymer Synthesis, the Science Center, and the Materials Research Center. A variety of modern instruments are available in individual laboratories and in the department’s Major Instrument Facility, which provides state-of-the-art equipment for nuclear magnetic resonance (both solution and solid state) and other techniques. This equipment, serviced and operated by a professional staff, is available to all researchers in the department. The central mass spectroscopy facility includes GC-MS, MALDI-TOF for macromolecular analysis, and LC-MS (ion trap) equipped. Other instruments available for research include NMR, visible, UV, fluorescence, atomic absorption and FTIR spectrophotometers, G.C. and HPLC equipment, electrochemical equipment, ESR spectrometers, DSC, DTA, TGA, and TMA instruments for thermal studies, and X-ray fluorescence and diffraction instruments. A molecular modeling laboratory contains computer workstations and a variety of sophisticated computer programs for molecular modeling, conformational analysis, energy calculation, and synthesis design.

Faculty*

Professors
Apple, T.M.—Ph.D. (University of Delaware); solid-state NMR spectroscopy.
Bailey, R.A.—Ph.D. (McGill University); coordination chemistry and chemistry of molten salts.
Benicewicz, B.C.—Ph.D. (University of Connecticut); polymer chemistry.
Breneman, C.M.—Ph.D. (University of California, Santa Barbara); physical organic chemistry.
Crivello, J.V.—Ph.D. (University of Notre Dame); polymer chemistry.
Cutler, A.R.—Ph.D. (Brandeis University); organometallic chemistry.
Interrante, L.V.—Ph.D. (University of Illinois); inorganic and solid-state materials synthesis.
Korenowski, G.M.—Ph.D. (Cornell University); laser spectroscopy, surface science.
Krause, S.—Ph.D. (University of California, Berkeley); physical chemistry of macromolecular solutions.
Linhardt, R.L.—Ph.D. (John Hopkins University); carbohydrate chemistry, biocatalysis.
Moore, J.A.—Ph.D. (Polytechnic Institute of Brooklyn); synthesis and reactions of polymers.
Wait, S.C., Jr.—Ph.D. (Rensselaer Polytechnic Institute); spectroscopy, vibrational and electronic spectroscopy.
Warden, J.T.—Ph.D. (University of Minnesota); ESR spectroscopy, biophysical chemistry.
Wentland, M.P.—Ph.D. (Rice University); medicinal chemistry.

Research Professors
Ferris, J.D.—Ph.D. (Indiana University); prebiotic chemistry, origins of life.
Wiedemeier, H.A.—D.Sc. (University of Munster); high-temperature and solid-state chemistry.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Associate Professors
Choma, C.T.—Ph.D. (University of Ottawa, Canada); biochemistry, protein design and synthesis.
Gillies, C.W.—Ph.D. (University of Michigan); microwave spectroscopy.
Stenken, J.A.—Ph.D. (University of Kansas); bioanalytical chemistry.

Assistant Professors
Akpalu, Y.—Ph.D. (University of Massachusetts, Amherst); polymer physical chemistry.
Colon, W.—Ph.D. (Texas A&M University); biophysical chemistry.
Ryu, C.Y.—Ph.D. (University of Minnesota); polymer physical and materials chemistry.

Clinical Assistant Professor
Carter, J.H., Jr.—Ph.D. (University of Oregon); physical chemistry, (Edward P. Hamilton Faculty Fellow).

Adjunct Faculty
Bello, S.C.—M.D. (SUNY Downstate Medical Center); general chemistry, biochemistry.
Choe, E.W.—Ph.D. (Illinois Institute of Technology); organic-polymer chemistry.
Dennin, M.—B.S. (Siena College); glassblowing.

Undergraduate Programs
The Chemistry Department offers a variety of opportunities to undergraduate students, ranging from four-year and accelerated degree programs to dual majors, minors, and specialization programs. All of these opportunities are explained in detail below.

Baccalaureate Programs
The B.S. in Chemistry curriculum is designed to meet the recommendations of the American Chemical Society Committee on Professional Training. At the same time, it provides ample opportunity for students to select electives that permit them to specialize in particular fields, to explore areas of potential interest, or to take unusual combinations of courses that will suit nontraditional career goals. The program emphasizes hands-on laboratory experience in the second and third years, and provides extensive opportunities to participate in research. Besides allowing students to prepare for careers that demand a good background in science and mathematics, the curriculum also offers a sound basis for careers in fields such as law, the health professions, management, and technical communication.

For students transferring from other universities, two-year colleges, or from other curricula at Rensselaer, previous chemistry courses will be evaluated on an individual basis. Normally, these courses will count toward the Rensselaer program. The content of laboratory courses can be adjusted to allow for prior experience. The department makes every attempt to accommodate transfer students whose backgrounds do not permit them to follow the normal course sequence.

Two paths are available leading to the American Chemical Society certified B.S. in Chemistry. One provides a traditional program; the other has an emphasis on biochemistry. Typical curricula, which require 128 credit hours for completion, are shown below.
### Traditional Curriculum

#### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I</td>
<td>4</td>
<td>CHEM-1200 Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-1100 Chemistry I</td>
<td>4</td>
<td>MATH-1020 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I</td>
<td>4</td>
<td>PHYS-1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2150 Equilibrium Chem. and Quantitative Analysis</td>
<td>4</td>
<td>CHEM-2030 Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-2210 Organic Compounds and Reactions</td>
<td>4</td>
<td>CHEM-2200 Organic Synthesis</td>
<td>4</td>
</tr>
<tr>
<td>MATH-2400 Intro to Differential Equations</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-4450 Macroscopic Physical Chemistry</td>
<td>4</td>
<td>CHEM-4150 Instrumental Analysis</td>
<td>4</td>
</tr>
<tr>
<td>CHEM-4060 Inorganic Chemistry II</td>
<td>4</td>
<td>CHEM-4460 Microscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>BCBP-4760 Molecular Biochem. I</td>
<td>4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

#### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-4900 Senior Seminar</td>
<td>0</td>
<td>CHEM-4620 Intro. to Polymer Chemistry</td>
<td>4</td>
</tr>
<tr>
<td>Electives</td>
<td>16</td>
<td>Electives</td>
<td>12</td>
</tr>
</tbody>
</table>

1. CHEM-1300 may be substituted for CHEM-1100 and ENGR-1600 may be substituted for CHEM-1200 by students transferring into chemistry.

2. Any combination of courses totaling 24 credits and meeting the H&SS distribution requirements is satisfactory.

3. A lecture-laboratory course.

4. CHEM-4310 may be substituted for this course.

5. At least one of the electives in this program must be in a science other than CHEM, PHYS or MATH.
Biochemistry Oriented Curriculum

### First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM-1200</td>
<td>Chemistry II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM-2150</td>
<td>Equilibrium Chem. and Quantitative Analysis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-2210</td>
<td>Organic Compounds and Reactions</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM-2030</td>
<td>Inorganic Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-2200</td>
<td>Organic Synthesis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>BIOL-2120</td>
<td>Intro. to Cell and Molec. Biology</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM-4450</td>
<td>Macroscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-4310</td>
<td>Bioorganic Mechanisms</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM-4150</td>
<td>Instrumental Analysis</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-4460</td>
<td>Microscopic Physical Chemistry</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>CHEM-4900</td>
<td>Senior Seminar</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>BIOL or BCBP Elective</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electives</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Spring</td>
<td>CHEM-4xxx</td>
<td>Bioanalytical Laboratory</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Electives</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

Within the chemistry curricula, students are encouraged to participate in available research opportunities. CHEM-2950 may be taken at any time, and students are urged to take at least three credits of this course. It may be taken more than once.

Students planning to pursue graduate studies in chemistry are urged to take at least 12 credits in chemistry courses beyond those required. CHEM-4990 is particularly valuable.

Students who take CHEM-4620, CHEM-4640, and either an advanced course or research in polymer chemistry satisfy the ACS recommendations for the polymer chemistry option.

**Electives**

Students should select electives in consultation with their adviser to ensure a balanced program. Combinations of electives that can provide appropriate depth in specific areas such as environmental chemistry, medicinal chemistry, polymer chemistry, chemical engineering, management, pre-law, and oth-

---

1. CHEM-1300 may be substituted for CHEM-1100 and ENGR-1600 may be substituted for CHEM-1200 by students transferring into chemistry.

2. Any combination of courses totaling 24 credits and meeting the H&S distribution requirements is satisfactory.

3. A lecture-laboratory course.

4. CHEM-4760 is an acceptable alternative.
ers can be provided by the adviser. Students interested in medicine as a career should include the follow-
ing courses among their elective choices. They are recommended before the senior year as preparation for
the qualifying exams required for admission to medical school.

- BIOL-1010 Introduction to Biology
- BIOL-1020 Introduction to Biology Laboratory
- BIOL-2120 Introduction to Cell and Molecular Biology
- BIOL-4270 Human Physiology I
- BIOL-4280 Human Physiology II
- BIOL-4620 Molecular Biology

In addition, two communications courses should be included among Humanities and Social Sciences elective
options.

**Dual Major Programs**

Students interested in both chemistry and another field may use the elective course options in one pro-
gram to take the required courses from another discipline to qualify for a dual degree. Examples are a B.S.
in chemistry and biology, or chemistry and physics, or chemistry and economics. Combinations with any
other science or H&SS discipline are usually easy to arrange, but students should seek counsel from their
advisers.

**Minor Programs**

The department offers a number of minor options for both chemistry and nonchemistry majors. In addi-
tion to the science minors detailed below, chemistry majors may minor in other disciplines through pro-
grams offered within other departments.

**Biochemistry Minor for Chemistry Majors**

This program is particularly advisable for chemistry students who wish to pursue scientific careers in medic-
inal research or at the interface of biology and chemistry. Students should take BIOL-2120, BCBP-4770,
and two courses from the following:

- BCBP-4710 Biochemistry Laboratory
- BIOL-4260 Cell Biology
- BIOL-4510 Molecular Genetics
- BIOL-4620 Molecular Biology
- BCBP-4310 Genetic Engineering
- BCBP-4210 Biophysical Methods
- BCBP-4810 Protein and Nucleic Acid Structure
- CHEM-4310 Biorganic Mechanisms
- BCBP-4780 or CHEM-4780 Protein Folding

**Biophysics Minor for Chemistry Majors**

This program is advisable for chemistry students who wish to pursue scientific careers in medicinal research
or at the interface of biology and chemistry. For this minor, students should take BIOL-2120, BCBP-4770,
and two courses from the following:

- MATH-4720 Mathematics in Medicine and Biology
- BIOL-4270 Human Physiology I
- BCBP-4210 Biophysical Methods
- BCBP-4810 Biological Spectroscopy
- PHYS-2510 Introduction to Quantum Physics
Astrobiology Minor for Chemistry Majors

Obtaining a minor in Astrobiology requires a minimum of 16 credits of course work that must include ASTR-4510 and ISCI-4500 (four credits each), two semesters of ISCI-4510 (One credit each) and two courses outside of the major field of study selected from the following:

- ENVE-2110 Introduction to Environmental Engineering
- BIOL-4440 Microbial Ecology
- BIOL-4620 Molecular Biology
- BCBP-4810 Biological Spectroscopy
- BCBP-4860 Protein and Nucleic Acid Structure
- CHEM-4810 Chemistry of the Environment
- ERTH-4070 Sedimentology
- ERTH-4540 Organic Geochemistry
- ASTR-2050 Introductory Astronomy and Astrophysics

For a double major, the requirement that the two selected courses must be outside the major field of study is reduced to one provided both majors are in the primary relevant areas of study (i.e. biology, chemistry, geology, and physics).

Chemistry minor for Non-Chemistry majors

Students not majoring in chemistry may receive a minor in this discipline by passing four four-credit courses at or above the 2000 level, one of which must include a laboratory. The combination cannot include both CHEM-2150 and CHEM- 4530.

Special Undergraduate Opportunities

Accelerated Programs

Students may elect to complete their B.S. degree in three years instead of four. To achieve this, they must take courses during the summer semesters and additional electives. Students with advanced placement standing in some courses are especially well situated for such arrangements. It is also possible for those not wishing to remain in Troy over the summer to take equivalent courses elsewhere and receive transfer credit.

An additional option is completion of the requirements in three and a half years. With advanced placement credit and additional courses during some academic semesters, summer work may be minimal.

B.S.-M.S. and B.S.-Ph.D. Programs

A student who is within 18 credit hours of the B.S. can apply for admission to the graduate program. With advanced placement credit, extra courses, and by starting research while still an undergraduate, the time required for the advanced degree can be reduced by a year or more. Students who enter the Chemistry graduate program through the 18-hour rule may be eligible for graduate teaching or research assistantship support.

Highly motivated students who carry out significant research as undergraduates may apply this toward their graduation thesis in a mentored program that can lead to the Ph.D. degree three years after the B.S. degree.

Students contemplating an accelerated program must consult with their adviser early their careers.

Undergraduate Research Programs

Chemistry majors at all levels are encouraged to participate in the research program of the department. Research may be taken for credit or supported financially through the Institute URP program and from faculty research funds. Participation may be during academic semesters or in the summer.
**Graduate Programs**

The Chemistry Department offers two graduate degrees—the Master of Science, and the Doctor of Philosophy. The M.S. and the Ph.D. require research and a thesis. Graduate students typically begin their studies with graduate courses in analytical, inorganic, organic, and physical chemistry. The courses that are required depend on the student’s background, area of interest, and performance in entering placement exams. Additionally, in consultation with the adviser, students may select a number of specialized advanced-level courses in chemistry, as well as from offerings in other departments that meet their needs. Chemistry graduate students may also select the biochemistry/biophysics option described earlier. Each student plans a program with his or her adviser to meet individual professional goals.

The Chemistry Department has well-developed research programs not only in the traditional areas of chemistry, but also in interdisciplinary areas that transcend traditional boundaries and that foster collaborative work with other departments. There are extensive collaborations among Chemistry, Chemical Engineering and Materials Science and Engineering in the areas of polymers/bio/nano/materials, and collaborative programs with Biology, Computer Science, Physics and Mathematical Sciences Departments, and the School of Engineering and the Center for Integrated Electronics. These, and off-campus collaborations which include Albany Medical College, the University at Albany and the New York State Wadsworth Laboratories provide essential connections between Chemistry and other areas vital to modern society. Cooperative programs with industry, national laboratories, and other universities are also part of the department’s research activities. Faculty members, visiting scholars, postdoctoral associates, graduate students, and undergraduates all participate in the research efforts of the department.

Supplementing courses and research projects are weekly seminars and colloquia in the various areas of chemistry. Scientists of national and international renown participate in these seminars.

Most first year graduate students receive support as teaching assistants, participating in undergraduate laboratory or workshop-mode chemistry courses under the direction of a faculty member. After they have chosen a research adviser graduate students are eligible for support as research assistants.

**Master’s Programs**

**Master of Science**

Students must complete 30 credit hours of research and course work, 15 of which must be at the 6000–9990 level. In addition, these students must submit a research thesis.

**Doctoral Programs**

To complete the Ph.D., students must meet divisional requirements in areas that their doctoral committee determines and accumulate 90 credit hours (60 beyond the M.S. degree) of research and course work. Satisfactory performance in an oral candidacy examination and a final defense of the doctoral thesis are also requirements. For any Ph.D. degree, the courses required will be specified based on the student’s background and research needs.

**Course Descriptions**

Courses directly related to all Chemistry curricula are described in the Course Description section of this catalog under the department code CHEM.
Computer Science

Chair: Jeffrey C. Trinkle

Executive Officer: Robert P. Ingalls

Computer Science Home Page: http://www.cs.rpi.edu/

Computer science is the study of the design, analysis, communication, implementation, and application of computational processes. The core subjects of this discipline include software systems (such as operating systems and networks) and programming languages (including design and other language translation tools). They also include computer hardware systems, the design and analysis of data structures and algorithms, and the theoretical basis of computation, in particular the complexity of computation. In addition to these core subjects, various application areas are open to students, including artificial intelligence, computer graphics, databases, scientific and numeric computation, computer vision, data mining, robotics, computational learning, and user-interface design.

At Rensselaer, education in computer science prepares students for solving applied, real-world problems and for conducting research in computer science. The program provides students a solid grounding in both theory and practice. The undergraduate program also provides a rigorous background in mathematics and science.

Rensselaer’s Computer Science Department offers its own well-equipped computer laboratories for instruction and research. There are 36 Sun Ultra 10 workstations running Solaris 8 in the public labs in the Amos Eaton building (rooms 117 and 217) as well as a dedicated Enterprise 450 serving 32 thin clients (room 215). Each of our Ultra 10 workstations includes a PC subsystem, providing Windows 2000 in the public labs. In the Networking and Distributed Simulation lab, there are 41 IBM x220 servers, along with 13 Cisco routers and a Myrinet Cluster for experimenting with different network layouts. Additionally, our Cisco lab contains over 50 interconnected Cisco routers, which support a number of network technologies such as FDDI, HSSI, ISDN, and Ethernet. Numerous other specialized research computers include a Silicon Graphics Origin 2000 with 12 CPUs. Also available are two robotics labs, a distributed/parallel computing laboratory, a computer-networking lab, and a multimedia database lab. Student offices contain more than 50 other Unix workstations and PCs. Supporting all of these is a network of file servers with more than 0.75 terabytes of storage, print servers, mail servers, and Web servers. Most offices have a 100Mb dedicated connection to the gigabit Ethernet backbone.

The department offers a B.S., M.S., and Ph.D. in Computer Science.

Research Innovations and Initiatives

Scientific Computation and Numerical Analysis

Specializations include adaptive and parallel computational techniques for solving problems that arise in large-scale scientific and engineering applications. Projects include the design and implementation of computer languages and compilers for scientific parallel computations, in particular techniques and methods for compile- and run-time optimization; adaptive methods for solving partial differential equations; and the development of finite element software and of fast and stable matrix algorithms. An especially interesting project involves modeling and simulation of biological and ecological systems.

Discrete Event Simulation

This work encompasses basic simulation techniques, such as parallel simulation protocols, Time Warp performance improvements, and run-time load balance of distributed simulations. The applications include
network monitoring and management, wireless networking, and biological and ecological simulations. The systems developed by faculty and publicly available include TEMPEST for spatially explicit spread of disease modeling and GALE for simulating genetic and evolutionary effects in epidemics, and GENESIS for simulating large communication networks.

Computer Vision
Computer vision and biomedical image analysis research in the Department of Computer Science covers a wide range of topics. Developing algorithms for registration and change detection, especially in the diagnosis and treatment of diseases of the human retina, is the largest current project. A related project studies the theory and application of robust estimation techniques in computer vision. A second research area focuses on the tracking of objects, both through video streams and range-image streams. Applications include surveillance, autonomous vehicle navigation, and audio-visual speech recognition. A third track involves the development of stochastic models for the interpretation of video data, for example traffic video.

Human Computer Interfaces
Research in this area is fundamental to the design and evaluation of systems that mediate between computers and humans, and ultimately leads to the creation of tomorrow's exciting new user interface software and technology. The ideal human-computer interface would be one where the user experience is such that the computer is no longer a distracting focus of attention but rather an invisible tool that empowers the individual user and facilitates natural and productive human-human collaboration. Faculty interests include assistive technology, universal access, intelligent user interfaces, interactive computing, multimedia information visualization, and multimodal environments.

Database Systems
This research area deals with the efficient and effective methods for storing, querying, and maintaining data from possibly disparate and heterogeneous resources. Data is used in many different applications from scientific data sets, sensor data, images, video and audio to hypertext documents, and data on stock market behavior. Research focuses on methods for caching data, querying large and distributed databases, and supporting applications such as computer-aided design and manufacturing and collaborative engineering.

Algorithm Design and Combinatorics
Projects involve the design and analysis of efficient algorithms for problems in combinatorial optimization using an experimental approach. Specific research projects include the development and evaluation of general learning and adaptive paradigms that output algorithms on specified input classes. Members of the theory group, along with participating graduate and undergraduate students, developed three large software systems for performing operations on sets and graphs, GraphPack, SetPlayer, and LINK, a comprehensive combinatorics and graph theory workbench for application and research. LINK is a collaborative effort of researchers from six universities.

Worldwide Computing
Worldwide computing research involves using a wide area network as a computing and collaboration platform. Current projects include the development of an actor-oriented programming language, and an Internet-based infrastructure for mobile and distributed computing.

Generic Programming
Research in this area focuses on new ways to design and implement computational methods so that they can adapt easily to different problems, providing solutions that are as efficient as programs written especially for each problem. Research interests span many diverse issues such as behavioral concept specifi-
cations, language design, compiler optimizations, efficient memory handling, and constructing and using libraries of multipurpose, high-performance software components. Results include the C++ Standard Template Library, which is based on joint research with colleagues in industry; new generic sorting and searching algorithms; and a new memory manager for C++ programs.

High Performance Data Mining and Computational Learning Systems
This research area deals with the theoretical and applied aspects of automated information extraction (knowledge discovery) from data. For large datasets, emphasis is placed on developing efficient, scalable, and parallel algorithms for various data mining techniques, in addition to the data management itself. Examples include association rules, classification, clustering, and sequence mining. For small datasets, the emphasis is on robust computational learning systems (supervised, unsupervised, and reinforcement) and their theoretical properties. Application areas include bioinformatics, computational genomics, Web mining, geographic information systems, and computational finance.

Robotics
Research in the robotics lab focuses on developing algorithms and automatic planners for robotic manipulation and mobile robotics. Current work includes motion planning for industrial assembly and parts feeding tasks, as well as algorithms for multiple robot coordination and control.

Computational Geometry
Current research in computational geometry concentrates on algorithms for the reconstruction of smooth geometric objects from their samples. Problems of interest include characterizing the conditions on sampling density, which allow a curve to be reconstructed from its samples. The reconstruction is homeomorphic and sufficiently close to the original and the algorithms developed to achieve the reconstruction. Also involved are the dependence of such algorithms on the dimension of the embedding space, related algorithms for the reconstruction of surfaces and manifolds, and finding the most concise representation of a manifold in terms of its samples. A second research track focuses on applications of computational geometry, particularly in robotic motion planning.

Bioinformatics
Bioinformatics is the science of managing, retrieving, analyzing, and interpreting biological data. Research is being carried out on topics such as multiple sequence alignment, sequence assembly, protein and RNA structure prediction, and regulatory network. Research also spans emerging areas like microarray data analysis, high dimensional indexing, database support, information integration, and data mining.

Computer Networking
Several projects in the department focus on the challenge of analyzing, managing and simulating the Internet. There is ongoing work on the Internet measurements and modeling. The Genesis project offers a novel approach to scalability and efficiency of parallel network simulation by integrating independently run domain or AS simulations into a distributed simulation. The ROSS system explores the fundamental functional and performance limits of reverse computation when applied to the modeling of large-scale network models. Based on these and other projects, we are developing software tools for collaborative on-line simulation architecture that provides pro-active and automated control functions for networks. Another investigated area is a hot-potato routing used in networks where the nodes have no buffers to store messages in transit and therefore is well suited for optical networks in which the messages are made from light which is hard to be stored in any medium. There is also research focusing on network security, from using machine learning for Denial of Service attack detection to security problems in wireless networks.
Faculty*

Professors
Flaherty, J.E.—Ph.D. (Polytechnic Institute of Brooklyn); numerical analysis, scientific computation, parallel computation, and adaptive methods.
Glinert, E.P.—Ph.D. (University of Washington); assistive technology, universal access, human-computer interaction, multimedia information visualization.
Goldberg, M.K.—Ph.D. (Institute of Mathematics, Novosibirsk, U.S.S.R.); algorithms for combinatorial optimization, experimental algorithm design and analysis, computational learning theory, graph theory.
Hardwick, M.—Ph.D. (Bristol University, U.K.); database systems for product modeling and manufacturing applications.
Luk, F.T.—Ph.D. (Stanford University); numerical linear algebra, parallel computing, image and signal processing.
Musser, D.—Ph.D. (University of Wisconsin); programming methodology, generic software libraries, formal methods of specification and verification, automated theorem proving.
Spooner, D.—Ph.D. (Pennsylvania State University); engineering database systems, object-oriented systems, database security, database browsing, and visualization.
Stewart, C.—Ph.D. (University of Wisconsin); computer vision, medical applications, robust statistics, computational geometry.
Szymanski, B.K.—Ph.D. (National Academy of Sciences, Warsaw, Poland); computer network management, modeling and simulation of computer and biological systems, distributed computing and scientific parallel computation.
Trinkle, J. C.—Ph.D. (University of Pennsylvania); robot planning, manufacturing automation, scientific computation, multibody dynamics, computational topology, human-machine interaction.

Research Professor
Lawrence, C.—Ph.D. (Cornell University); bioinformatics, transcription regulation, Bayesian statistics and Markov chain Monte Carlo algorithms.

Associate Professors
Adali, S.—Ph.D. (University of Maryland); multimedia database systems, information integration, query optimization.
Krishnamoorthy, M.S.—Ph.D. (Indian Institute of Technology); programming environments, design and analysis of combinatorial algorithms, performance issues in the Internet, analysis of Web documents, compiler design.
Yener, Bulent, Ph.D.—(Columbia University); Systems research in data and communications networks; quality of service on the Internet; routing, access control, and security in mobile wireless networks, network design and optimization.

Research Associate Professor
Newberg, Lee Ph.D.—(University of California, Berkeley) Bioinformatics, computational modeling of complex systems.

Assistant Professors
Akella, S.—Ph.D. (Carnegie Mellon University); robotics, computer-aided manufacturing, geometric algorithms.
Busch, C. —Ph.D. (Brown University); distributed and parallel systems, communications networks.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Carothers, C.—Ph.D. (Georgia Institute of Technology); experimental distributed systems, simulation, wireless networks, computer architecture.

Drineas, Petros—Ph.D. (Yale University); Randomized and approximation algorithms, linear algebra, information retrieval and data mining.

Freedman, D.—Ph.D. (Harvard University); computer vision, image processing, computational geometry, computational topology.

Huang, W.—Ph.D. (Carnegie Mellon University); robotic manipulation, mobile robotics, motion planning.

Kettnaker, V.—Ph.D. (Cornell University); computer vision, stochastic models.

Magdon-Ismail, M.—Ph.D. (California Institute of Technology); machine learning, computational finance, bioinformatics.

Varela, C.A.—Ph.D. (University of Illinois at Urbana-Champaign); Internet computing, concurrent and distributed systems, programming languages, coordination models, mobile code, databases, the Web.

Zaki, M.—Ph.D. (University of Rochester); data mining and knowledge discovery in databases, parallel computing, bioinformatics.

Lecturer


Clinical Professor

Danchak, M.M.—Ph.D. (Rensselaer Polytechnic Institute); human-computer interaction, usability, information visualization, techniques for distance learning and human learning models.

Professor Emeritus

McNaughton, R.—Ph.D. (Harvard University); automata theory, formal languages, combinatorics of words.

Adjunct Faculty

Ingalls, R.—Ph.D. (University of Connecticut); systems programming, network programming.

Kotfila, D.—M.Div. (Yale University) Director, Cisco Networking Academy.

Joint Appointment with Mathematical Sciences—Professors

Isaacson, D.—Ph.D. (New York University); applied mathematics, numerical analysis.

McLaughlin, H.W., II—Ph.D. (University of Maryland); analysis, differential equations, approximation theory.

Joint Appointments with Electrical, Computer, and Systems Engineering—Professors

Gerhardt, L.A.—Ph.D. (State University of New York, Buffalo); digital signal processing, communications, voice and image processing, pattern recognition, adaptive systems, computer integrated manufacturing, course development.

Wozny, M.J.—Ph.D. (University of Arizona); computer graphics, computer-aided design, digital simulation, rapid prototyping systems.

Joint Appointments with Electrical, Computer, and Systems Engineering—Associate Professors

Franklin, W.R.—Ph.D. (Harvard University); computational geometry, graphics and CAD algorithms and data structures, parallel algorithms, cartography, expert system verification and validation.

Kalyanaraman, S.—Ph.D. (Ohio State University); ATM and Internet traffic management, multimedia networking, IP telephony, performance analysis, Internet pricing.

Joint Appointment with Mechanical, Aerospace, and Nuclear Engineering—Professor

Shephard, M.—(Cornell University); scientific computation, mesh generation, adaptive and parallel finite element methods.
Joint Appointment with Mechanical, Aerospace, and Nuclear Engineering—Associate Professor Jansen, K.E.—Ph.D. (Stanford University); large scale scientific computing with emphasis on fluid dynamics. Topics include turbulence modeling, finite element formulations, error estimation, design of software frameworks, parallel computing.

Joint Appointment with Cognitive Science—Professor Bringsjord, S.—Ph.D. (Brown University); logic, philosophical logic, philosophy of artificial intelligence.

Undergraduate Programs

The undergraduate degree program in computer science provides an excellent background for students entering the work force directly upon graduation and for those pursuing graduate studies. Students majoring in computer science will study such topics as artificial intelligence, computer graphics, theory of computation, operating systems, robotics, data mining, databases, systems programming, parallel computing, and scientific numerical computing. A graduating computer science major should

- be an expert software developer, with knowledge of several programming paradigms
- have a solid understanding of the mathematical/theoretical underpinnings of computer science
- be able to express himself/herself well both orally and in writing
- understand current computing technologies and be prepared to quickly adapt to new technological developments

Baccalaureate Programs

All computer science students are assigned a faculty adviser to assist them with their interests and career goals throughout their academic career. As the typical 124-credit-hour B.S. curriculum leading the B.S. in computer science shown below exhibits, flexibility is a hallmark of the Rensselaer computer science program. Students may explore related areas such as mathematics, electrical engineering, computer engineering, management, and psychology.

Computer Science Curriculum

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fall</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I 4</td>
<td>MATH-1020</td>
<td>Calculus II 4</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I * 4</td>
<td>CSCI-1200</td>
<td>Computer Science II 4</td>
</tr>
<tr>
<td></td>
<td>Science Option 4</td>
<td>MATH-2800</td>
<td>Intro. to Discrete Structures 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>Hum. or Soc. Sci. Elective 4</td>
<td></td>
</tr>
</tbody>
</table>

* Students may skip CSCI-1100 and replace it with any other CS course.
### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-2300</td>
<td>Data Struct. and Algorithms 4</td>
<td>CSCI-2400</td>
<td>Mathematics Option 4</td>
</tr>
<tr>
<td>CSCI-2500</td>
<td>Computer Organization 4</td>
<td></td>
<td>Models of Computation 4</td>
</tr>
<tr>
<td></td>
<td>Science Option 4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 4</td>
<td></td>
<td>Free Elective 4</td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-4430</td>
<td>Programming Languages 4</td>
<td>CSCI-4210</td>
<td>Operating Systems 4</td>
</tr>
<tr>
<td></td>
<td>Computer Science Option 4</td>
<td></td>
<td>Free Elective 4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective 4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective 4</td>
</tr>
<tr>
<td></td>
<td>Free Elective 4</td>
<td></td>
<td>Free Elective 4</td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-4440</td>
<td>Software Design and Doc. 4</td>
<td></td>
<td>Computer Science Option 4</td>
</tr>
<tr>
<td></td>
<td>Computer Science Option 4</td>
<td></td>
<td>Free Elective 4</td>
</tr>
<tr>
<td></td>
<td>Free Elective 4</td>
<td></td>
<td>Free Elective 4</td>
</tr>
</tbody>
</table>

### Options

#### Science

Two four-credit courses in different disciplines chosen from the following: astronomy, biology, chemistry, earth and environmental science, and physics. The Pass/No Credit option cannot be used for these courses. The course ERTH-1030 cannot be used to satisfy this requirement.

#### Computer Science

Eleven additional credit hours of computing courses at the 4000 or 6000 level. For this purpose, courses in the series CSCI-4xxx, CSCI-6xxx, ECSE-46xx, and ECSE-47xx may be used, excluding reading and independent study courses. The Pass/No Credit option cannot be used for these courses.

#### Mathematics

One additional mathematics course at the 2000 level or above. The Pass/No Credit option cannot be used for this course.

### Dual Major Programs

Computer science students can obtain a dual major with any other major offered on the Rensselaer campus. In many cases students can obtain a dual major within the 124 credits of a single degree, since many courses can be counted twice. Among the popular majors often combined with computer science are philosophy, mathematics, physics, management, Electronic Media Arts, and Communication, and engineering (the latter requires additional credits hours).

### Minor Programs

A computer science minor requires CSCI-1200, CSCI-2300, and three additional four-credit courses at the 2000 level or above. At least two of these must have a CSCI code and at least two must be at the 4000 or 6000 level. One course may be chosen from the ECSE-x6xx or ECSE-x7xx family. Courses required by name for the student’s major cannot be used for the minor.
Accelerated Programs
Students may be admitted to the graduate program in Computer Science when they are within 18 credits of completing their B.S. Students may be able to complete the B.S. and M.S. in a shorter than usual time by using advanced placement credit, taking courses during the summer, or taking extra courses during the academic year. A variety of joint degree programs can be arranged, depending on the student’s background, interests, and desired rate of progress. Any joint degree program requires that the student apply to and be accepted to the graduate program.

Special Undergraduate Opportunities
The Computer Science Department strongly encourages students to take part in the following special programs.

Cooperative Education
Numerous opportunities exist for computer science majors, and students are urged to pursue at least one co-op experience during their academic career. More detailed information on this program is available in the School of Science introduction section and the Educational Programs and Resources section of this catalog.

Undergraduate Research Program
This program allows students to participate in faculty research activities. The department urges students to take advantage of these opportunities, through which students can earn either pay or course credit. Additional benefits may include being named co-authors on journal papers or the opportunity to make presentations at professional conferences. Additional information is available in the School of Science introduction section and the Educational Programs and Resources section of this catalog.

Cisco Networking Academy
The Cisco Networking Academy provides extensive hands-on learning in networking. A lab of over 70 routers and switches simulates the backbone of the Internet and is always available for student use. The Academy prepares students for the following certifications: Cisco Certified Network Associate (CCNA), Cisco Certified Network Professional (CCNP), and Cisco Certified Internetwork Expert (CCIE).

Graduate Programs
The Department of Computer Science offers M.S. and Ph.D. degrees in computer Science. The department also offers a computer science M.S. and Ph.D. with a specialization in computational science, and a Ph.D. with specialization in computational molecular biology.

Applications for the M.S. or Ph.D. in computer science should be sent to the Graduate Admissions Office to be received no later than January 15 for fall admission; October 1 for spring admission. Applicants must provide transcripts, two letters of recommendation, a statement of goals, and GRE scores. Each student’s background is expected to include courses in discrete mathematics, calculus, data structures, computer organization, and computing languages, none of which can be counted toward the graduate degree. Admission is extremely competitive, and meeting the minimum requirements does not assure admission.
Master’s Programs

M.S. in Computer Science
In addition to meeting the degree requirements of the Office of Graduate Education, a candidate must plan a degree program and complete the plan of study form in consultation with a faculty adviser. A degree program must include at least 30 credits, at least 18 of which must be at the 6000 level. It must include two required courses, CSCI-6050 (can be replaced by CSCI-6480) and CSCI-4210 (can be replaced by CSCI-6140). At least two courses must be taken from the computer systems area, and at least one course must be taken from computer theory area and one course from the computer applications area. Finally, it must include a master’s thesis and regular attendance at department colloquia.

M.S. in Computer Science Specializing in Computational Science and Engineering
Applicants apply to this program in the usual manner. However, student backgrounds are expected to include courses in calculus, elementary linear algebra, elementary differential equations, discrete mathematics, data structures, and numerical computing. Courses in computer organization and computing languages are recommended. Students lacking some of this material may be admitted but will be expected to acquire this knowledge during their studies. This may require taking courses beyond the normal degree requirements.

Students must complete a plan of study that includes 30 credits at the 4000 and 6000 levels with 1) at least six credits in numerical analysis and/or scientific computation; 2) at least eight credits in an area of natural science or engineering; 3) at least one course in each of software and hardware systems; and 4) a significant (three to four credit) software project. At least 18 credits must be at the 6000 level and students should attend the computer science colloquium and the scientific computation seminars.

Students interested in further study within this area should refer to the Ph.D. in Computer Science Specializing in Computational Science and Engineering below.

Doctoral Programs

Ph.D. in Computer Science
Students must demonstrate skill using computational tools and high achievement in scholarship and independent research. During the first year, the student focuses on obtaining a breadth of knowledge in computer science. At the end of the first year, the student must pass a written doctoral qualifying examination. This examination covers the material of five courses: CSCI-6050, CSCI-4020, CSCI-6140, CSCI-4250, and CSCI-4430.

The second year is devoted to research exploration and selection of a doctoral committee. By the end of the second year, the student must pass a research qualifying exam demonstrating breadth of knowledge in the research area.

In the third year, the student develops a detailed understanding of the chosen research area and prepares a research proposal. The student must pass an oral candidacy exam by the end of the third year. The candidacy exam is an oral exam focusing on a thesis proposal and administered by the student’s doctoral committee. The student begins by presenting the thesis proposal and then is questioned by the committee.

In addition to the above requirements, the student must earn a total of 90 credits beyond the bachelor’s level. Between 45 and 60 credits must be course credits. The remaining credits are for dissertation research. All students must have courses in three of the following four areas on their undergraduate or graduate transcript: database systems, artificial intelligence, numerical computing, and computer graphics/user interfaces. In addition, all doctoral students must have had at least three courses in mathematics at the junior/senior level, and they must demonstrate programming ability on a substantial programming project.
The area requirements, the mathematics requirement, and the programming requirement can be satisfied by course work completed prior to entering the Ph.D. program. Finally, all doctoral students are expected to have presented at least two public lectures on their research prior to their defense.

**Ph.D. in Computer Science Specializing in Computational Science and Engineering**

Students must complete 90 credits of course work and research beyond the B.S. degree, with at least 45 credits in formal course work. They must take 1) at least 12 credits in an area of natural science or engineering; 2) at least nine credits in numerical analysis and/or scientific computation; and 3) at least one course in software systems, hardware systems, and visualization. They must further demonstrate mathematical sophistication by having taken at least eight credits of 4000- or 6000-level mathematics courses (exclusive of numerical analysis) and programming ability by having done a substantial software project.

After one year of study, students must pass a written qualifying examination in 1) numerical computing (material equivalent to CSCI-4800), 2) software and hardware systems (material equivalent to CSCI-4020, CSCI-4250, and CSCI-4430), and 3) a scientific or engineering field of specialization.

Upon passing this examination, students begin dissertation research with a chosen adviser. After their third year of graduate study, students are expected to pass an oral candidacy examination that focuses on their research. Subsequent to passing this examination, students must present two public lectures on their research and write and defend a dissertation.

Doctoral course requirements are inclusive of those for the M.S. degree. As with the M.S. degree, applicants apply in the usual manner, but should have backgrounds including courses in calculus, elementary linear algebra, elementary differential equations, discrete mathematics, datastructures, and numerical computing. Courses in computer organization and computing languages are recommended. The mathematical and programming proficiency requirements can be satisfied by work done outside of the Ph.D. degree program.

**Ph.D. in Computer Science with a Specialization in Computational Molecular Biology**

The completion of the human genome sequence and related genome resources has revolutionized biology and the biomedical sciences. As a result a great demand for individuals skilled in analyzing genomic data and in developing associated algorithms and database has developed. While the pharmaceutical and biotech industries were the first to begin hiring individuals with this background, the demand from academic institutions subsequently blossomed. To help meet this demand, the Computer Science Department offers a Doctor of Philosophy degree in Computer Science with a specialization in Computational Molecular Biology. This program is a Computer Science degree program with strong cross-disciplinary training in molecular biology / biochemistry, probability and statistics, and bioinformatics. Students will conduct their research and classroom activities under the direction of Computer Science faculty and faculty in other departments.

Admission: Students apply to the Computer Science Department in the usual manner. Student backgrounds are expected to include courses in calculus, elementary linear algebra, higher-level computer languages, algorithms & data structures, introductory organic chemistry (CHEM-2210 or equivalent), and introductory biology. Students lacking some of this material may be admitted but will be expected to acquire this knowledge during their studies. This may require taking courses beyond the normal degree requirements.

Doctor of Philosophy: Students must complete 90 credits of course work and research beyond the B.S. Degree, with at least 45 credits in formal course work. They must take (1) at least 12 credits in molecular or cell biology / biochemistry, (2) at least nine credits in probability, statistics, machine learning and
bioinformatics, and (3) at least 12 credits in CS including at least one course each in software systems, theory of computation, and applications (in addition to courses covered on the qualifying exam, database systems, computational molecular biology, and data mining courses are recommended). They must further demonstrate programming ability by having done a substantial software project.

After one year of study, students must pass an oral qualifying examination in (1) probability and statistics (material equivalent to Course MATP-4600), (2) CS (material equivalent to courses CSCI-4020 Computer Algorithms, and CSCI-4430 Programming Languages, CSCI-6050 Computability, and Complexity), (3) and biochemistry I (BCBP-4760) or molecular biology (BIOL-4620).

After passing this examination, students begin dissertation research with a chosen adviser. After their third year of graduate study, students are expected to pass an oral candidacy examination that focuses on their research. Subsequent to passing this examination, students must present at least two public lectures on their research and write and defend a dissertation.

The probability and statistics, programming proficiency, and molecular biology/biochemistry requirement can be satisfied by work done outside of the Ph.D. degree program.

Course Descriptions

Courses directly related to all Computer Science curricula are described in the Course Description section of this catalog under the department code CSCI.

Earth and Environmental Sciences

Chair: Frank Spear

Department Home Page: http://www.rpi.edu/dept/geo

Over the past few decades, the earth sciences have undergone major changes. Primarily stimulating these changes have been the reinterpretation of Earth history and processes with regard to plate tectonics, along with the more recent challenges of local, regional, and global environmental problems. Highly cognizant of these changes, Rensselaer’s instruction in modern earth science is wide ranging and offers many courses and opportunities for individual study.

At Rensselaer, students learn about the Earth using techniques ranging from seismological and satellite-tracking investigations of crustal motions to state-of-the-art geochemical instruments. The latest techniques for simulating Earth processes include high-pressure experimentation and computer modeling. A broad choice of courses is available, ranging from quantitative, computer-oriented aspects of the geological to field experience and geochemical approaches. The program includes the study of the Earth’s component materials, the development of its structures and surface features, the processes by which these change with time, and the origin, discovery, and protection of its resources—water, fuels, and minerals.

The Troy area is well situated for field-based study of problems in hard-rock and surficial geology, as well as ground and surface water science. The department enjoys fruitful relationships with nearby university, industrial, and government geoscience groups within 10 miles of the campus. All students have access to these resources as well as to the laboratory and computer facilities of the Institute, which has a strong commitment to education and research in science and engineering.

There are numerous opportunities for students to engage in field-oriented projects. In addition, students may obtain summer employment with oil, geological engineering, or hydrologic consulting companies, or they may participate in a Rensselaer faculty member’s field-oriented research project.
Research Innovations and Initiatives

The diverse interests of the Earth and Environmental Sciences faculty lead to a wide variety of projects that stimulate educational programs at both the graduate and undergraduate levels. Undergraduate students are encouraged to enroll in the Undergraduate Research Program (URP), which involves them in front-line research for credit or pay. Graduate students pursue specialized study in consultation with their faculty advisers, whose research interests are matched on an individual basis.

Geochemistry and Petrology

Ongoing studies in geochemistry include the distribution of trace elements between minerals in metamorphic and igneous systems, the physics and chemistry of fluids transport in the crust and mantle, experimental studies of chemical reactions and transport deep in the Earth, and accessory minerals as geochronometers. The tectonic evolution of mountain belts is being investigated through the examination of metamorphic rocks in diverse regions such as New England, the Adirondacks, the Alps, and British Columbia.

Geophysics

Research in geophysics includes field studies of the seismology and tectonics of Asia, Indonesia, the western U.S., and the southwestern Pacific. Using the Global Positioning System (GPS), plate motions and earthquake strains are monitored and computer models of plate motions and faulting are developed. Seismic tomography is used to reveal deep structures of the lithosphere and mountain belts. Seismic, magnetic, geodetic, and gravity methods are used to probe local structures, including ancient faults and hydrologic conduits.

Hydrogeology and Environmental Geochemistry

Ongoing research includes investigations of organic pollutant transport, dispersion, and degradation in surface and groundwater. Also under way are studies of heavy-metal-contamination histories of local water bodies, development of methods for tracing and predicting contaminant behavior, and the use of stable isotopes as fingerprints and traces of environmental contamination.

Research Facilities

Students have access to the department’s electron microprobe, gamma spectrometer, gas chromatographs, spectrophotometers, differential thermal apparatus, gravimeter, magnetometer, 12-channel seismograph, electrical resistivity equipment, GPS receivers, and seismograph stations. Also available are X-ray diffraction and fluorescence equipment, atomic absorption and optical emission spectrometers, and scanning electron microscopes as well as two isotope ratio mass spectrometers with dual microinlet, an elemental analyzer, and gas chromatographic sample introduction systems for continuous flow and compound-specific analyses. PCs, Macs, and Unix workstations in the department are linked to the Institute’s computer network.
Faculty*

Institute Professor
Watson, E.B.—Ph.D. (Massachusetts Institute of Technology); experimental geochemistry and petrology.

Professors
Abrajano, T.A.—Ph.D. (Washington University); isotope and environmental geochemistry.
McCaffrey, R.—Ph.D. (University of California, Santa Cruz); tectonics, seismology, geodesy.
Roecker, S.—Ph.D. (Massachusetts Institute of Technology); geophysics, seismology, and geodesy.
Spear, F.S.—Ph.D. (University of California, Los Angeles); petrology, geochemistry.

Associate Professors
Bopp, R.F.—Ph.D. (Columbia University); environmental geochemistry.

Professors Emeriti
Bayly, M.B.—Ph.D. (University of Chicago); structural geology, rheological properties of earth materials.
Friedman, G.M.—Ph.D. (Columbia University); D.Sc. (University of London); sedimentology.
Gaffey, M.J.—Ph.D. (Massachusetts Institute of Technology); planetary science.
Katz, S.—Ph.D. (Columbia University); seismology, geophysics.
LaFleur, R.G.—Ph.D. (Rensselaer Polytechnic Institute); geomorphology, glacial geology, water resources.
Miller, D.S.—Ph.D. (Columbia University); geochemistry, isotope geology, fission track research.

Research Associate Professors
Cherniak, D.—Ph.D. (University at Albany, SUNY); geochemical kinetics.
Wark, D.A.—Ph.D. (University of Texas, Austin); igneous petrology, volcanology.

Research Assistant Professor
Shuster, E.—Ph.D. (Rensselaer Polytechnic Institute); environmental geology, hydrogeology.

Research Scientists
Price, J.—Ph.D. (Oklahoma University); experimental petrology.
Pyle, J.—Ph.D. (Rensselaer Polytechnic Institute); metamorphic petrology, trace element geochemistry.
Williams, C.—Ph.D. (University of Arizona); geophysics, tectonics.

Undergraduate Programs

The undergraduate curricula are flexible so that students may work in interdisciplinary areas while maintaining emphasis in earth and environmental sciences. Students are encouraged to take electives in their field of interest, including some outside the department. These should form a coherent group and be approved by their adviser. Students are encouraged to use the flexibility available to their own advantage. The department adviser will consult with each student individually to arrange an optimal program in geology, hydrogeology, geochemistry, geophysics, or environmental geoscience.

Students transferring from other curricula can graduate with their class provided that they enter the department by the beginning of the third year and that they have maintained satisfactory grades in their first two years.

Baccalaureate Programs

Each of the programs shown below require a total of 124 credit hours. The first program leads to a B.S. in Geology and the second to a B.S. in Hydrogeology.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Geology Curriculum

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
</table>
| MATH-1010 | Calculus I | ...........................................4
| CHEM-1100 | Chemistry I | ...........................................4
| ERTH-1100 | Geology I  | ...........................................4
| Hum. or Soc. Sci. Elective | 4 |

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
</table>
| MATH-2010 | Multivar. Calc. and Matrix Algebra | .4
| PHYS-1100 | Physics I | ...........................................4
| ERTH-2330 | Earth Materials | ..........................4
| Hum. or Soc. Sci. Elective | 4 |

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
</table>
| ERTH-2100 | Introduction to Geophysics | ...............4
| ERTH-2120 | Structural Geology | ...........................................4
| ERTH-4xxx | Geology Elective | ..........................4
| Hum. or Soc. Sci. Elective | 4 |

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
</table>
| ERTH-xxxx | Electives | ...........................................16

Geology Group options (Three courses from the following group)

- ERTH-4190  Environmental Measurements
- ERTH-4340  Igneous and Metamorphic Petrology
- ERTH-4540  Organic Geochemistry
- ERTH-4690  Aqueous Geochemistry
- ERTH-4650  Seismology
- ERTH-4710  Groundwater Hydrology
- ERTH-4750  Geographic Information Systems in the Sciences

Field Group Option

- ERTH-4970  Out of Classroom Experience in Earth Science
- ERTH-4980  Senior Field Thesis
- Field Camp
- Undergraduate Research Program (URP)

Electives

The following are recommended as electives for the geology curriculum:

- BIOL-4320  Geomicrobiology

---

1 E&ES Electives - two courses (8 credits) at the 4000 level are required for the major.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-4850</td>
<td>Principles of Ecology</td>
</tr>
<tr>
<td>CHEM-2210</td>
<td>Organic Compounds and Reactions</td>
</tr>
<tr>
<td>CHEM-4450</td>
<td>Macroscopic Physical Chemistry</td>
</tr>
<tr>
<td>CIVL-2630</td>
<td>Introduction to Geotechnical Engineering</td>
</tr>
<tr>
<td>CIVL-4150</td>
<td>Soil Mechanics</td>
</tr>
<tr>
<td>ENVE-4310</td>
<td>Applied Hydrology and Hydraulics</td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Introduction to Differential Equations</td>
</tr>
<tr>
<td>MATH-4600</td>
<td>Advanced Calculus</td>
</tr>
<tr>
<td>MATH-4700</td>
<td>Foundations of Applied Mathematics</td>
</tr>
<tr>
<td>MATH-4800</td>
<td>Numerical Computing</td>
</tr>
<tr>
<td>MATH-4820</td>
<td>Introduction to Numerical Methods for Differential Equations</td>
</tr>
<tr>
<td>MTLE-2020</td>
<td>Introduction to Ceramic Materials</td>
</tr>
<tr>
<td>MTLE-4100</td>
<td>Thermodynamics of Materials</td>
</tr>
<tr>
<td>WRIT-4120</td>
<td>Technical and Professional Communication</td>
</tr>
</tbody>
</table>

**Hydrogeology Curriculum**

**First Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010</td>
<td>Calculus I</td>
</tr>
<tr>
<td>CHEM-1100</td>
<td>Chemistry I</td>
</tr>
<tr>
<td>ERTH-1100</td>
<td>Geology I</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1020</td>
</tr>
<tr>
<td>CHEM-1200</td>
</tr>
<tr>
<td>ERTH-1200</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2010</td>
<td>Multivar. Calc. and Matrix Algebra</td>
</tr>
<tr>
<td>PHYS-1100</td>
<td>Physics I</td>
</tr>
<tr>
<td>CSCI-xxxx</td>
<td>Computer Science Elective</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400</td>
</tr>
<tr>
<td>PHYS-1200</td>
</tr>
<tr>
<td>Elective</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2210</td>
<td>Field Methods</td>
</tr>
<tr>
<td>ERTH-2120</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Electives</td>
<td>4</td>
</tr>
</tbody>
</table>

**Spring**

<table>
<thead>
<tr>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2140</td>
</tr>
<tr>
<td>Elective</td>
</tr>
<tr>
<td>Elective</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-4710</td>
<td>Groundwater Hydrology</td>
</tr>
<tr>
<td>ENVE-2110</td>
<td>Intro. to Environmental Engr.</td>
</tr>
<tr>
<td>ERTH-4190</td>
<td>Environmental Measurements</td>
</tr>
<tr>
<td>Elective</td>
<td></td>
</tr>
</tbody>
</table>

**Electives**

A total of 30 credit hours of free electives is required. These electives should be designed to provide a depth of understanding in a subdiscipline of hydrogeology (e.g., geology, mathematics, chemistry, physics,  

^1 See Field Group Option under Geology Curriculum.
biology, computer science, engineering, etc.). A limited list of suggested courses for free electives includes the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2100</td>
<td>Introduction to Geophysics</td>
<td>CIVL-4240</td>
<td>Finite Element Methods</td>
</tr>
<tr>
<td>ERTH-4070</td>
<td>Sedimentology</td>
<td>CSCI-1200</td>
<td>Computer Science II</td>
</tr>
<tr>
<td>ERTH-4540</td>
<td>Organic Geochemistry</td>
<td>DSES-4140</td>
<td>Statistical Analysis I</td>
</tr>
<tr>
<td>ERTH-4690</td>
<td>Aqueous Geochemistry</td>
<td>DSES-6110</td>
<td>Introduction to Applied Statistics</td>
</tr>
<tr>
<td>BIOL-4620</td>
<td>Molecular Biology</td>
<td>ECSE-4510</td>
<td>Discrete Time Systems</td>
</tr>
<tr>
<td>BIOL-4700</td>
<td>Fresh Water Ecology Laboratory</td>
<td>ENVE-4220</td>
<td>Environmental Law</td>
</tr>
<tr>
<td>CHEM-2210</td>
<td>Organic Compounds and Reactions</td>
<td>MATP-4600</td>
<td>Probability Theory and Applications</td>
</tr>
<tr>
<td>CHEM-4450</td>
<td>Macroscopic Physical Chemistry</td>
<td>PHYS-2350</td>
<td>Experimental Physics</td>
</tr>
<tr>
<td>CHEM-4460</td>
<td>Microscopic Physical Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Minor Programs**

The department offers opportunities to minor in the following:

**Geology**

Students not majoring in geology may take a minor by completing from the ERTH group at least 16 credit hours, eight of which should be at the 4000 level. ERTH-1030 and 1040 (Natural Sciences) do not count towards the minor.

**Astrobiology**

The Earth and Environmental Sciences Department participates in a multidisciplinary minor in astrobiology for students majoring in geology or other disciplines. To complete this minor, students must take a minimum of 16 credits of course work in this field. These courses include ASTR-4510 and ISCI-4500, four credits each, and two semesters of the one-credit course ISCI-4510. A further two courses outside the major field of study are also required, selected from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTR-2050</td>
<td>Intro. to Astr. and Astrophysics</td>
<td>BIOL-4760</td>
<td>Molecular Biochemistry I</td>
</tr>
<tr>
<td>BCBP-4810</td>
<td>Biological Spectroscopy</td>
<td>CHEM-2250</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>BCBP-4860</td>
<td>Protein and Nucleic Acid Structure</td>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
</tr>
<tr>
<td>BIOL-4320</td>
<td>Geomicrobiology</td>
<td>ENVE-2110</td>
<td>Intro. to Environmental Engineering</td>
</tr>
<tr>
<td>BIOL-4440</td>
<td>Microbial Ecology</td>
<td>ERTH-4070</td>
<td>Sedimentology</td>
</tr>
<tr>
<td>BIOL-4620</td>
<td>Molecular Biology</td>
<td>ERTH-4540</td>
<td>Organic Geochemistry</td>
</tr>
</tbody>
</table>

The requirement that two selected courses must be outside of the major field of study is reduced to one in the case of a dual major, provided that both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

**Hydrogeology**

Students not majoring in hydrogeology may take a minor by taking ERTH-4710, ERTH-4180, and electing from the ERTH group at least two additional courses except for ERTH-1030 and ERTH-1040.

**Interschool Minor in Energy**

Students interested in developing a broad, multidisciplinary background in energy to complement their more focused major program should consider this minor. See the Interdisciplinary Programs and Research Section of the School of Humanities and Social Sciences portion of this catalog for details.
**Accelerated Programs**

An accelerated program with emphasis in geophysics is available for students interested in combining a B.S. and an M.S. in geology. Students interested in developing an accelerated course of study in this or another area of geological sciences should consult their adviser.

**Special Undergraduate Opportunities**

The department has several unique educational opportunities that are detailed below.

**Out-of-Classroom Experience**

In consultation with his or her adviser, each hydrogeology student may select and engage in an out-of-classroom experience for up to four hours of course credit. The experience should have intellectual content relevant to the student’s educational or career goals. Envisioned as a summer activity, this experience usually occurs after the sophomore or junior year, although it could also occur during the fall or spring terms.

Appropriate experiences might include an individual or group research project (on or off campus), an independent study project, a co-op assignment, a public service internship, or study abroad. A written proposal and a final written report submitted for evaluation to the Earth and Environmental Sciences Department Undergraduate Curriculum Committee is required.

**Environmental Science Concentration**

The environmental science degree program is offered to students with an interest in a broad interdisciplinary degree directed toward understanding and finding solutions for the environmental challenges that face modern civilization. The environmental science degree has a core science requirement of 38 credit hours (10 courses). The student then selects from one of several concentration areas, one of which is geology.

**Environmental Studies Program**

Building on the unusual strength and breadth of Rensselaer’s synthesis of engineering, science, and the humanities and social sciences, the Environmental Studies Program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies.

Participating students take a broad range of basic courses in their first two years and then choose one of five majors: economics (with a concentration in a specific area of science), hydrogeology, science, technology, and society (with an environmental focus). Students may also choose the Ecological Economics, Values, and Policy dual major program, which includes economics and science, technology, and society. To complement their major program, students may earn a wide variety of minors. All the majors in the program offer their own environmental minors, and the Schools of Architecture and Management offer special environmental courses as well. Graduates of the Environmental Studies Program will not be narrow specialists; they will receive the kind of multidisciplinary education that is required to address environmental problems.

See Interdisciplinary Programs and Research in the School of Humanities and Social Studies for a complete description of the program.

**Graduate Programs**

Research programs leading to the M.S. and Ph.D. degrees are available in geochemistry, geophysics, hydrogeology, and igneous and metamorphic petrology.

Interdisciplinary research takes place with other groups, including the Darrin Fresh Water Institute and
the Departments of Biology, Physics, Civil and Environmental Engineering, and Materials Science and Engineering. Recently the department has been involved in the interdisciplinary Origins of Life initiative. Applicants to degree programs must arrange for their Graduate Record Examination (GRE) general test scores to be sent to the department. Those who cannot take the test because of illness, residence overseas, etc., should attach explanations to their applications.

**Master’s Programs**
The department offers M.S. degrees in geology and hydrogeology and a professional master’s degree in applied groundwater science.

Candidates for the M.S. degrees in geology and hydrogeology must complete 30 hours of graduate study based on an approved plan of study. A thesis based on original research is usually submitted. This requirement may be waived at the discretion of the candidate’s adviser.

For the professional master’s degree in applied groundwater science, candidates must also complete 30 credit hours of graduate study based on an approved plan of study. However, no thesis is required.

**Doctoral Programs**
Candidates for the Ph.D. degree must fulfill the requirements of the Office of Graduate Education. Evidence of success in graduate-level study and research must be shown. There is no language requirement.

**Course Descriptions**
Courses directly related to all Earth and Environmental Sciences curricula are described in the Course Description section of this catalog under the department code ERTH.

**Mathematical Sciences**

**Chair:** Donald Drew

**Chair of the Graduate Committee:** William Siegmann

**Departmental Home Page:** [http://www.math.rpi.edu/index.html](http://www.math.rpi.edu/index.html)

Through the centuries, mathematics has been a central feature of our intellectual and technological development. Today its role in the physical sciences and engineering is well established. Its role in the life and social sciences, medicine, management, and the arts is undergoing remarkable growth—a virtual mathematization of the culture. The Department of Mathematical Sciences is directly engaged in this process through its educational and research programs. Our focus is the study and development of mathematical and computational methods and their application to problems of contemporary significance to our society.

The Department of Mathematical Sciences provides an in-depth education in both the foundations of mathematical thought as well in the applications of mathematics to real-life phenomena. For this reason, we offer a baccalaureate degree with a specialization in mathematics, applied mathematics, mathematics of computation, or operations research. The department’s programs are also designed to provide a broad spectrum of opportunities for students. This flexibility allows students and advisers to tailor programs to individual objectives and talents. As a result, the curricula are equally advantageous for individuals who will seek immediate employment upon graduation, for those who plan graduate-level education in the mathematical sciences, and for those who will apply their education to pursuits outside the mathematical arena. Our graduates have entered careers in law, medicine, engineering, management, and psychology, as well as in pure and applied mathematics, computer science, and operations research.
At the graduate level, Rensselaer is especially well-known as a center for advanced study and research in applied mathematics. The department’s M.S. and Ph.D. programs emphasize:

- Methods of applied mathematics, including ordinary and partial differential equations, approximation theory, asymptotic analysis, functional analysis, and numerical analysis;
- Applications in the physical sciences, biological sciences, and engineering;
- Scientific computing;
- Mathematical programming, including nonlinear, combinatorial, and multiple objective optimization and their applications.

At the highest level, continual interplay between the construction of the mathematical model and the solution of the resulting mathematical problem characterizes applied mathematics. The ideal applied mathematician, therefore, must be knowledgeable both in mathematics and in at least one field in which problem areas are found. A sound knowledge of the application area assists in constructing suitable models, and a high level of mathematical judgment and expertise may be required to solve the resulting mathematical problems.

**Research Innovations and Initiatives**

Faculty research activities in the Department of Mathematical Sciences center on applied mathematics, analysis, scientific computing, mathematical programming, and operations research. The faculty’s interest in applied research often leads to a synthesis of techniques from two or more research areas. Further, the formulation, solution, and interpretation of a problem often contain ideas that can be applied to problems in other areas. Focusing different research areas on real problems and the diversity of applications of real problem solutions creates an atmosphere of interaction and cooperation within the department and the university, as well as with other major research institutions.

**Numerical Analysis and Scientific Computation**

Investigations range from the study of fundamental problems in linear algebra to the development and analysis of numerical schemes for solving particular physical or life science problems. Research activities include the numerical solution of optimization problems, inverse eigenvalue problems, and free-boundary problems; finite difference and finite element methods for stiff initial and boundary-value problems; and methods of resolving problems involving composite materials. Applications of these studies include reacting flows, shockwave propagation, semiconductor performance, biomathematics, acoustic signal propagation, and incompressible flow in various geometries.

**Inverse Problems**

This research involves the recovery of internal biological, mechanical, electric, or magnetic properties of a system from boundary, spectral, or scattering data. The physical system is modeled by a partial differential or ordinary differential equation with specific unknown terms representing, for example, stiffness in an elastic system or electric permittivity in an electromagnetic system. The goal of this work is to find the unknown properties from indirect measurements. Current research applies functional analysis, perturbation theory, numerical analysis, and optimization to determine optimal datasets, to study the nonlinear dependence of the unknown physical quantities on the available data, and to obtain approximations of the nonlinear operators that will yield efficient reconstruction algorithms. There is a significant role for modeling, analysis, scientific computation, and algorithm development to obtain solutions to these problems.
Dynamical Systems
This research concentrates on the theory of dynamical systems and its applications in physics and engineering. Dynamical systems arise as mathematical models in various applications such as mechanics, optics, electric circuits, solid-state physics, fluid dynamics, optimal control, neural science and other fields. This research aims to discover and explain new and important phenomena found in experimental and numerical studies. Often involved is modeling a real-life problem by a dynamical system and then applying the ideas and methods of the theory to explain and predict complex behavior. Theoretical research is conducted in chaotic dynamics, Hamiltonian systems (KAM theory and applications, theoretical mechanics), bifurcation theory, and related fields. Mathematical methods used come from analysis, topology, differential geometry, combinatorics, and other fields. Computation may be used as an experimental tool.

Wave Propagation
These studies focus on the behavior of acoustic wave propagation. A major area of interest is underwater sound transmissions. Mathematical models are being developed and analyzed to describe the influences of ocean environmental features (such as internal waves and sediment variations) on the study of the propagation of signals in both frequency and time domains, and to improve the accuracy of known numerical methods. Improved numerical and asymptotic methods are derived and tested, providing new ways to extract information from complex propagation environments. Stochastic propagation effects are modeled and analyzed, and results are used to explain variability observed by ocean scientists. Results are extended and applied to acoustic propagation environments ranging from the atmospheres of Jupiter and the Earth to the upper layer of the Earth's crust.

Mathematical Programming and Operations Research
Mathematical programming endeavors to find optimal solutions for a broad range of problems including medical, financial, scientific, and engineering problems. Research is conducted on the development, evaluation, and comparison of serial and parallel algorithms for a variety of mathematical programming problems. Current research topics include interior point methods for linear, integer, and nonlinear programming; branch-and-bound and branch-and-cut approaches to integer programming problems; column generation methods; financial optimization; and genetic algorithms and tabu search. Also under investigation are mathematical programming approaches to problems in artificial intelligence such as machine learning, neural networks, support vector machines, pattern recognition, and planning. This research also considers combining operations research and artificial intelligence problem-solving methods, scalability of these methods to large problems in data mining, mathematical programming approaches to other areas in computer science such as database query optimization, and stochastic programming.

Biomathematics
Mathematical biology is a very active area of applied mathematical research. This is an interdisciplinary endeavor, with a strong interaction with biological and biomedical scientists. Projects of current interest include cardiac imaging and the use of computer graphics to construct pictures of the heart, mechanoreception, mathematical modeling of biological systems that transform mechanical stimuli (e.g., sound, touch, etc.) into ionic or neural signals and molecular systems in cells. Also being studied are nonlinear ionic diffusion in polyelectrolytic gels and the mechanics of multiphasic tissues like cartilage and the cornea. Numerical analysis, asymptotics, and functional analysis are used to investigate mathematically posed problems resulting from the models.
Fluid Mechanics
Methods of applied mathematics are being used to study how fluids behave under a wide spectrum of conditions. The physical problems usually lead to partial differential equations, which may be linear or nonlinear. Current problems deal with fluid mechanics in engineering systems, the flow and stability of two-phase mixtures, the transition from laminar to turbulent flow in boundary layers, fluid mechanical models of atmospheric events and the theory of flow in a gas centrifuge. Studies also include the evolution of non-Newtonian (e.g., polymer) fluid flow.

Combustion Theory
Investigations include mathematical modeling of combustion and flame propagation phenomena, and analysis of the resulting systems of nonlinear ordinary and partial differential equations. Topics of current interest are bifurcation and stability of reactive systems, evolution and interaction of waves in reactive gases, combustion and vortex breakdown in swirling flows, and transition from deflagration to detonation in granular explosives.

Applied Geometry
Included are problems dealing with surface design, curve design, robot path planning, packing, tiling, computational geometry, and artificial intelligence as it applies to geometry. Students take advantage of related courses in electrical engineering, mechanical engineering, computer science, and mathematics.

Approximation Theory
This branch of mathematics strives to understand the fundamental limits in optimally representing different signal types. “Signals” here may mean a database of digital audio signal, a collection of digital mammograms, solutions of a class of integral equations, or triangulated compact surfaces acquired by a 3-D scanner. These signals are typically modeled mathematically based on their intrinsic smoothness or oscillatory characteristics. Current research effort involves the design and analysis of various multiresolution techniques that have provable optimality properties for these models. Such optimal representations are invariably the key ingredients to successful data compression, estimation, and computer-aided geometric design. Exploited tools range from mathematical analysis (e.g., Littlewood-Paley theory) to fast numerical algorithms, to information theory, to algebraic and differential geometry, and to spline and subdivision theory.

Complex Systems
This includes an investigation into nonlinear phenomena that arise in such diverse areas as semiconductor laser theory, nonlinear and fiber optics, surface water waves, acoustic waves and gas lasers. Although these topics are seemingly disconnected and have different physical characteristics, they all can be viewed as complex systems composed out of interacting particles or waves. There is a general theoretical framework for their description called weak turbulence theory. The research in this area involves development of weak turbulence theory and how to use this theory to study complex systems.

Bioinformatics
The massive volume of new data being produced by genome sequencing projects point to an increasing need for bioinformatics. This is a highly interdisciplinary field, involving faculty in mathematical sciences, biology, computer science, chemistry and several departments in the school of engineering. RPI has established a joint bioinformatics center with the nearby Wadsworth Laboratories in the New York state Department of Public Health. Current activities at RPI comprise the development and application of algorithms that aim to solve biological problems using DNA and amino acid sequence, structure, and related information. Some of the problems addressed are the search for patterns in biomolecular sequences that are functionally important, such as transcription binding sites; the prediction of structure or function from
nucleic acid or protein sequence data; the development of methods and databases to classify large amounts of biological information, and the development of algorithms and software that are important for current biotechnology applications.

**Faculty***

**Professors**

**Boyce, W.E.**—Ph.D. (Carnegie Institute of Technology); applied mathematics, mathematics education (emeritus).

**Cheney, M.**—Ph.D. (Indiana University); inverse problems, wave propagation, applications in engineering and biology, partial differential equations.

**Drew, D.A.**—Ph.D. (Rensselaer Polytechnic Institute); applied mathematics, fluid mechanics, mathematical biology.

**Ecker, J.G.**—Ph.D. (University of Michigan); mathematical programming, multiobjective programming, geometric programming, mathematical programming applications, ellipsoid algorithms.

**Fleishman, B.A.**—Ph.D. (New York University); nonlinear differential equations, mathematics education (emeritus).

**Habetler, G.J.**—(Carnegie Institute of Technology); functional analysis, numerical analysis (emeritus).

**Handelman, G.H.**—Ph.D. (Brown University); applied mathematics, elasticity, wave propagation, mathematical biology (emeritus).

**Herron, I.**—Ph.D. (Johns Hopkins University); applied mathematics, fluid mechanics, hydrodynamics, stability.

**Holmes, M.**—Ph.D. (University of California, Los Angeles); perturbation methods, biomechanics, nonlinear continuum mechanics.

**Isaacson, D.**—Ph.D. (New York University); mathematical physics, biomedical applications.

**Jacobson, M.J.**—Ph.D. (Carnegie Institute of Technology); applied mathematics, acoustic and electromagnetic wave propagation (emeritus).

**Kapila, A.**—Ph.D. (Cornell University); applied mathematics, combustion, fluid mechanics.

**Lim, C.C.**—Ph.D. (Brown University); mathematical modeling, vortex dynamics, applications of graph theory.

**McLaughlin, H.W.**—Ph.D. (University of Maryland); applied geometry.

**McLaughlin, J.R.**—Ph.D. (University of California, Riverside); inverse bioelasticity problems, inverse vibration and inverse scattering problems, wave propagation, analysis, applied mathematics.

**Royburd, V.**—Ph.D. (University of California, Berkeley); applied mathematics, combustion theory.

**Rubenfeld, L.A.**—Ph.D. (New York University); applied mathematics, mathematics, science education.

**Siegmund, W.L.**—Ph.D. (Massachusetts Institute of Technology); applied mathematics, wave propagation.

**Zuker, M.**—Ph.D. (Massachusetts Institute of Technology); bioinformatics.

**Associate Professors**

**Bennett, K.P.**—Ph.D. (University of Wisconsin); mathematical programming, operations research, machine learning, data mining, artificial intelligence.

**Kovacic, G.**—Ph.D. (California Institute of Technology); applied mathematics, nonlinear dynamics, nonlinear optics.

**Mitchell, J.E.**—Ph.D. (Cornell University); mathematical programming, integer programming, interior point methods, column generation methods, financial optimization, stochastic programming.

**Piper, B.R.**—Ph.D. (University of Utah); computer-aided geometric design, numerical analysis, computer graphics.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Schwendeman, D.W.—Ph.D. (California Institute of Technology); applied mathematics, scientific computing.

Assistant Professors
Kramer, P.R.—Ph.D. (Princeton University); turbulent diffusion, stochastic processes.
Lvov, Y.—Ph.D. (University of Arizona); mathematical physics and nonlinear phenomena.
Yu, T.P.-Y.—Ph.D. (Stanford University); wavelets and applications in signal and image reconstruction.

Clinical Assistant Professors
Blackford J.T.—Ph.D. (Ohio State University); algebraic coding theory, combinatorics, codes over rings.
Kiehl, M.—Ph.D. (Rensselaer Polytechnic Institute); biomathematics.
Schmidt, D.A.—Ph.D. (Rensselaer Polytechnic Institute); graph theory, qualitative matrix analysis, mathematics education.

Research Assistant Professor
Nolan, C.J.—Ph.D. (Rice University); medical and seismic imaging using microlocal analysis.

Joint Appointments with Computer Science—Professors
Flaherty, J.E.—Ph.D. (Polytechnic Institute of Brooklyn); scientific computation, numerical analysis, applied mathematics.
Rogers, E.H.—Ph.D. (Carnegie Institute of Technology); VLSI architecture, computer applications (emeritus).

Undergraduate Programs
Mathematics has always been the cornerstone of scientific development. Rensselaer’s aim is to provide an education in mathematics, both as a subject in itself and as a discipline to aid in the development of other social and scientific fields. The undergraduate mathematics program educates students in a variety of mathematical areas. The flexibility in this program, with its numerous options, permits selection of courses ranging from pure theory (which builds a foundation for more advanced studies), to applied subjects focusing on mathematical modeling and the solution of real-world problems. In particular, Rensselaer’s Department of Mathematical Sciences is one of the few American programs with a strong faculty orientation toward mathematics applications. Reflecting this emphasis are the many undergraduate courses dealing with areas of mathematical applications and the applied flavor with which department faculty typically teach them.

Baccalaureate Programs
Four curricula leading to a B.S. in Mathematics have been designed to permit the construction of programs that reflect individual student interests and career objectives. These curricula include:

- Mathematics—a traditional program emphasizing the elements of pure and applied mathematics.
- Applied Mathematics—emphasizing both the modeling of physical phenomena and methods of analyzing the resulting mathematical problems.
- Mathematics of Computation—a program bridging mathematics and computer science, with emphasis on numerical methods for solution of problems in science and engineering.
- Mathematics of Operations Research—emphasizing the use of mathematics in developing and studying analytical models of discrete systems, especially those that arise in management, engineering, and social sciences.
These four curricula share several common features. First, they each contain nine free electives that permit students to design unique programs. These electives also allow students to concentrate on a subject in addition to mathematics, to obtain a broad-based education, or to complement their mathematics program. A second common feature is the Humanities and Social Sciences requirement of 24 credits. Finally, completion of all four curricula requires a total of 124 credits.

An immediate choice among these four curricula is not necessary, since for the first two years, all mathematics students follow the same basic curriculum. This initial two-year course of study is outlined below and is followed by sample junior/senior curricula for each of the department’s four undergraduate programs. Additional details and up-to-date descriptions of the mathematics courses, including special topics courses, are available at the department’s Web site, http://www.math.rpi.edu/index.html.

The First Two Years

First Year

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I ..........................................4</td>
<td>MATH-1020</td>
<td>Calculus II ..........................................4</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I ..................................4</td>
<td>Science Elective ..................................4</td>
<td></td>
</tr>
<tr>
<td>Science Elective  ................. 4</td>
<td>Elective ..................................4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1900</td>
<td>Art and Science of Math I .........................1</td>
<td>MATH-1910</td>
<td>Art and Science of Math II .........................1</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MATH-2010</td>
<td>Multivar. Calc. and Matrix Algebra ................4</td>
<td>MATH-2400</td>
<td>Intro. to Differential Eqns. ....................4</td>
</tr>
<tr>
<td>Science Elective  ................. 4</td>
<td>Science Elective  ................. 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective ..................................4</td>
<td>Elective (MATH-2700 suggested) ....4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the above curriculum, the first-year seminar courses MATH-1900 and MATH-1910 are not required, but are strongly recommended. This weekly seminar course for math majors presents interesting and challenging mathematical problems and ideas for discussion. Also deserving particular attention is MATH-2700, a second semester sophomore course that provides a good background for junior and senior mathematics courses.

The science electives must include at least three different School of Science disciplines outside of math. Since CSCI-1100 is already required, the science electives must include two or more other disciplines. Also, two of these science electives must be in the same discipline. Note that mathematical science includes all courses with MATH and MATP codes (and any course cross listed with a MATH or MATP course), computer science includes all courses coded CSCI (and any course cross listed with a CSCI course), and courses coded PHYS and ASTR are considered separate disciplines.

Mathematics Curriculum

Third Year

<table>
<thead>
<tr>
<th></th>
<th>Credit hours</th>
<th></th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>MATH-4200</td>
<td>Mathematical Analysis I .........................4</td>
<td>MATH-4210</td>
<td>Mathematical Analysis II .........................4</td>
</tr>
<tr>
<td>Mathematics Option  ................. 4</td>
<td>MATH-4010</td>
<td>Abstract Algebra .........................4</td>
<td></td>
</tr>
<tr>
<td>Elective ..................................4</td>
<td>Elective ..................................4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The above curriculum provides a broad and basic education in mathematics. It is especially suited to those intending to continue on to graduate education in mathematics or some other scientific and engineering field. Considerable flexibility is built into this program to allow students and their advisers to tailor programs to individual objectives. As a result, by choosing appropriate mathematical options, the curriculum is equally useful to those seeking immediate employment upon graduation.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences. Those planning to go on to graduate work should be sure to take MATH-4100.

**Applied Mathematics curriculum**

**Third Year**

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4200 Mathematical Analysis I ...................4</td>
<td>Mathematics Option.........................4</td>
</tr>
<tr>
<td>MATH-4800 Numerical Computing ........................4</td>
<td>Mathematics Option .......................4</td>
</tr>
<tr>
<td>Elective ..................………….4</td>
<td>Elective ..............................4</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-4700 Foundations of Applied Math ........4</td>
<td>Mathematics Option.........................4</td>
</tr>
<tr>
<td>Mathematics Option.........................4</td>
<td>Elective ..............................4</td>
</tr>
<tr>
<td>Elective ..................……………………4</td>
<td>Elective ..............................4</td>
</tr>
<tr>
<td>Elective ..................……………………4</td>
<td>Elective ..............................4</td>
</tr>
</tbody>
</table>

The above curriculum stresses courses that involve the construction, analysis, and evaluation of mathematical models of real-world problems and those areas of mathematics most widely used to solve them. Thus, it prepares students to deal with mathematical problems that arise in science, engineering, or management. Applied mathematics students enjoy considerable flexibility, but are urged to acquire a solid background in the three principal areas of applied mathematics, which are modeling, analysis or solution methods, and numerical analysis.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences. It is recommended that students take PHYS-1100 and PHYS-1200 and those who may continue on to graduate school should consider taking MATH-4210 and MATH-4100.
Mathematics of Computation Curriculum

Third Year

Fall  | Credit hours  | Spring  | Credit hours
--- | --- | --- | ---
MATH-4200 Mathematical Analysis I | 4 | | 
MATH-4800 Numerical Computing | 4 | Computation Option | 4
Elective | 4 | CS Option | 4
Hum. or Soc. Sci. Elective | 4 | Elective | 4

Fourth Year

Fall  | Credit hours  | Spring  | Credit hours
--- | --- | --- | ---
MATH-xxxx CS Option | 4 | Mathematics Option | 4
Elective | 4 | Elective | 4
Elective | 4 | Elective | 4

Computers and computational methods play an important role in all fields of science and engineering. Thus, the above curriculum focuses on the mathematical development, analysis, and application of numerical methods. Surrounding this main focus are courses that build mathematical expertise in analysis, modeling, and applications. This curriculum also allows the flexibility to pursue courses in computer science and other fields of science and engineering.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences. The computation option is either MATH-4820 or MATP-4820. The CS options are any 2000-level or higher courses from Computer Science (i.e., courses coded CSCI and not cross listed with any math course).

It is also recommended that students take PHYS-1100, PHYS-1200, and CSCI-1200. Those planning to continue on to graduate school should consider taking MATH-4210.

Mathematics of Operations Research Curriculum

Third Year

Fall  | Credit hours  | Spring  | Credit hours
--- | --- | --- | ---
MATH-4200 Mathematical Analysis I | 4 | Elective | 4
Elective | 4 | Mathematics Option | 4
Hum. or Soc. Sci. Elective | 4 | MATP-xxxx OR Option | 4

Fourth Year

Fall  | Credit hours  | Spring  | Credit hours
--- | --- | --- | ---
Mathematics Option | 4 | Mathematics Option | 4
Mathematics Option | 4 | Elective | 4
Elective | 4 | Elective | 4
Elective | 4 | Elective | 4

The above curriculum emphasizes the use of mathematics for developing and studying analytical models of systems. These models are used to form better decisions in areas such as management, engineering, and the social sciences. In mathematical programming, a problem is modeled as an objective function with constraints on the possible solutions, then the resulting model is optimized. The models are solved using computer programs. Algebra, analysis, and discrete mathematics all play a role in analyzing the models.
and in developing computer algorithms to solve them. Frequently, the inputs and outcomes of the model are not known with certainty, thus probability and statistics are used.

Students should note that the mathematics options listed above are any 4000-level or higher course from the Department of Mathematical Sciences, plus up to two 4000-level or higher courses from Decision Science (DSES) or Computer Science (CSCI). In other words, of the four mathematics options, a minimum of two must be coded MATH or MATP.

Also, the OR option in this curriculum is either MATP-4600 or MATP-4820.

**Minor Programs**

Students not majoring in mathematics may receive a minor in math by taking four courses at the 4000 level or above from the MATH and MATP course groups. These courses should form a coherent program and have the prior approval of the chairman of the Department of Mathematical Sciences.

**Dual Major Programs**

The requirements for a dual major are described in the introduction to the Mathematical Sciences Department. Interest in such programs is increasing, and recent combinations have included math and physics, math and computer science, and math and psychology. Typical schedules for such combinations can be found at the department’s Web site under dual majors.

**Accelerated Programs**

Qualified students may earn a B.S. and M.S. degree in the same or different areas in a shorter-than-usual time. They may do so through the use of advanced placement credit, by taking additional courses during the fall and spring semesters, and/or by taking summer courses.

For example, a student with advanced placement credit for Calculus I and II may earn the B.S. and M.S. degrees within four years by taking an additional course each regular fall and spring semester. Since a student may take up to 21 credit hours per semester at no additional charge, it may be possible to earn both degrees for the cost of a B.S. alone. As a second example, rather than taking more courses during the academic year, a student may earn two degrees in four years by taking eight courses distributed over three summers.

Such a joint degree program requires that the student apply to and be accepted by the Office of Graduate Education at an appropriate stage. A wide variety of joint degree programs can be arranged depending on the student's background, interests, and desired rate of progress. The interested student should consult the faculty adviser to design an optimum program.

**Graduate Programs**

The Department of Mathematical Sciences offers programs leading to the M.S. and Ph.D. degrees. Each curriculum is highly flexible, and each student’s program of study is individually designed.

A departmental colloquium series, in which both mathematics faculty and guest lecturers present current research work, supplements course work. In addition, graduate students organize a weekly seminar, in which they present material from their research. Moreover, each semester, faculty and students organize informal seminars that explore topics of mutual interest. In a special course called Introduction to Research in Mathematics, each week a faculty member discusses his or her research program and describes current problems for graduate students to investigate. In addition, through formal course work and individual contact with the faculty, students become familiar with all departmental research activities. The department’s Web site also provides an overview of these research activities and lists the faculty working in each area.
Undergraduates with backgrounds in mathematics or any related major with significant mathematical content are admissible to the graduate program.

**Master’s Programs**
The department offers the M.S. degree in both Applied Mathematics and Mathematics.

**Applied Mathematics**
The emphasis of this program is on mathematics and how it is employed to study science, engineering, or management problems. It stresses construction, analysis, and evaluation of mathematical models of real-world problems, and those areas of mathematics that are most widely used to solve them. The requirements for this degree allow students to prepare for entry into the Ph.D. program in applied mathematics or for employment in business, industry, or government.

The student must meet the Office of Graduate Education requirements and follow a plan of study acceptable to this office and the Department of Mathematical Sciences. Each student’s program of study must include:

- At least four graduate (6000) level courses of four credits each, of which at least two must be in math (MATH-6xxx or MATP-6xxx)
- At least four courses coded MATH or MATP of four credits each
- At least one three- or four-credit course at the 4000 or 6000 level outside the department (i.e., not coded MATH or MATP and not cross listed with any department course), selected in consultation with the math adviser
- Each student must participate in a capstone professional experience, by registering for and completing one of the following alternatives: 1) a Master’s Project in Mathematics, MATH-6980; 2) a Master’s Practicum, MATH-6970, such as a graduate cooperative internship or active participation in the Applied Mathematics Industry Workshop (a department faculty member must approve your plans in advance and must certify its satisfactory completion; 3) two 6000-level MATH courses, with second digit either 4, 5, 6, 7 or 8 (one may be an appropriate Special Topics course MATH-696x, subject to adviser’s approval; 4) two 6000-level MATP courses (one may be an appropriate Special Topics course MATP-696x, subject to adviser’s approval).

**Mathematics**
The student must meet the Office of Graduate Education requirements and follow a plan of study acceptable to this office and the Department of Mathematical Sciences. The plan of study should represent a reasonably broad program in mathematics and must contain:

- At least four graduate (6000) level courses of four credits each, of which at least two must have numbers in the range MATH-6000 to MATH-6390
- At least four courses coded MATH or MATP of four credits each
- Each student must participate in a capstone professional experience, by registering for and completing one of the following alternatives: 1) a Master’s Project in Mathematics, MATH-6980; 2) a Master’s Practicum, MATH-6970, such as a graduate cooperative internship (a department faculty member must approve your plans in advance and must certify its satisfactory completion).

**Doctoral Programs**
Students working for the doctorate must demonstrate high achievement both in scholarship and in independent research. All programs must follow the general rules of the Office of Graduate Education.

The Ph.D. degree results from following a program of study in mathematics or in applied mathematics. In either case, the student’s program of study must include:
At least six, four-credit (nonthesis) graduate mathematics courses (i.e., those with numbers MATH-6xxx or MATP-6xxx)

At least one three- or four-credit course at the graduate (6000) level outside the department (i.e., not coded MATH or MATP and not cross listed with any department course), selected in consultation with the math adviser

At most 30 thesis/research credits

All doctoral students must pass a written preliminary exam as well as an oral qualifying examination, and complete an oral candidacy presentation. Descriptions of these requirements can be found on the department’s Web site.

In addition, the course MATH-6591 Research in Mathematics is strongly suggested. Any deviations from these requirements must have the approval of the Department's Graduate Committee.

Course Descriptions

Courses directly related to all Mathematical Sciences curricula are described in the Course Description section of this catalog under the department code MATH or MATP.

Physics, Applied Physics, and Astronomy

Chair: Gwo Ching Wang

Associate Chair: Philip A. Casabella

Department Home Page: http://www.rpi.edu/dept/phys/physics.html

Physics is the source of new concepts about the nature of the universe and is a driving force for new technologies. The fundamental physics research of one generation frequently leads to the applied physics and technology of the next.

The Department of Physics, Applied Physics, and Astronomy programs prepare undergraduate students to contribute to these new concepts and technologies through innovative teaching methods that combine student-faculty interactions, computer-based education, and “hands-on” experience in modern laboratories. The curricula are flexible so that students can prepare for either technical employment upon graduation or for graduate study in physics, applied physics, or engineering. Physics also provides an excellent foundation for a nontechnical career. Another important aspect of the physics program is student-faculty research projects involving collaboration between physics undergraduates and faculty on a variety of research topics at the forefront of the field.

The Department of Physics, Applied Physics, and Astronomy’s graduate programs lead to the M.S. and the Ph.D. in physics. These degrees are available in several research areas that are summarized below. For graduate students specializing in Astronomy and Astrophysics, the M.S. degree is available either in astronomy or physics with specialization in astrophysics.

Rensselaer’s graduate study in physics prepares students for a variety of careers including industrial research and development, government laboratory research, and university research and teaching. The department conducts both fundamental and applied research, often in collaboration with researchers from other Rensselaer departments, industry, or the National Laboratories. Characterizing the Physics Department’s intellectual climate are lively interactions between theorists and experimentalists with common research interests. Colloquia and department seminars supplement course work. As an important part of their graduate education, students collaborate with faculty members to make original research contributions in their area of specialization.
Research Innovations and Initiatives

Astronomy and Astrophysics
Research in the astrophysics group includes astrobiology, the chemistry of the interstellar medium, and many areas of galactic and extragalactic astronomy. Research in astrobiology and interstellar chemistry describes how interstellar clouds evolve into new solar systems. Current interest focuses on spectroscopic detection of organic molecules in interstellar dust and gas and their contribution to the organic inventory of protoplanetary disks. Theoretical projects include simulations of protostellar collapse, multifluid magnetohydrodynamic shock waves, and shock chemistry. Research in galactic and extragalactic astronomy includes the structure and formation of the galactic halo, metallicity gradients in the galactic thick disk, properties of stars with strong Balmer absorption, optical properties of quasars, and astronomical data mining. The astrophysics group makes use of ground-based telescopes located at world class observing sites in Hawaii, Australia, Chile, and South Africa. Rensselaer also has access to data from major satellite facilities including the Hubble Space Telescope, Chandra, and the Infrared Space Observatory; and large ground-based astronomy projects, including the Sloan Digital Sky Survey and the Two Micron All Sky Survey (2MASS).

Biophysics
Current work focuses on cells in tissue culture. When mammalian cells are cultured on small gold electrodes, changes in the cells’ morphology and motion can be inferred from the measured impedance of the electrodes. This method, in addition to the study of cell behavior in vitro, can be used effectively as a biosensor. Now under investigation are cell migration, toxicology, and metastatic potential of cancer cells.

Condensed Matter Physics
This research program concentrates on three areas: surfaces, interfaces, and nanostructures; optical and electronic materials; and electronic transport. New research concepts, materials, and techniques are developed for high technology applications. Many research projects are interdisciplinary.

Experimental and theoretical work on surfaces, interfaces, and nanostructures involves the deposition, growth, and characterization of metals, semiconductors, and insulators from monolayers to multilayers. The phenomena that are studied include homo- and hetero-epitaxy, initial stages of epitaxy, nucleation of thin films, surface phase transitions, and interface (solid-solid and solid-liquid) structure and bonding. Techniques include Auger electron spectroscopy, X-ray photoelectron spectroscopy, high resolution low-energy electron diffraction, reflection high-energy electron diffraction, atomic force microscopy, scanning tunneling microscopy, ballistic-electron-emission microscopy, X-ray absorptions spectroscopy, X-ray crystallography, and ellipsometry. The department's major facilities include ultrahigh vacuum evaporation, III–V group IV molecular beam epitaxy, and the extensive facilities of the Microelectronics Clean Room. Theoretical work also includes applications of statistical physics and large-scale simulations to study the dynamics of natural, artificial, and social systems, including ecological systems, agent-based models, and social networks.

The optical and electronic materials under study include wide bandgap semiconductors, polymers, semiconductor nanoparticle composites, dielectrics, and magnetic thin films. Optical characterization facilities include Raman, Brillouin, and Rayleigh scattering, photomodulation spectroscopy, photothermal deflection spectroscopy, magneto-optic Kerr effect, and Faraday rotation.

Electron transport in semiconductor and metallic materials are under way. This research is expected to enhance understanding of transport in nanostructures. The experimental work includes studies of ballistic electron transport in ultrathin epitaxial multilayers, electrical resistance of metallic films, and plasma wave electronics in high electron mobility transistors. The electron transport in nanoscale systems (single molecule to atomic wire to carbon nanotube) is studied using the state of the art first principles calculation. The current research includes spin assisted transport (Spintronics) at the nanoscale. The computational facilities in the theory group include in house Linux cluster of about 100 processors and the group has
access to National Super Computer facilities.

Other experimental facilities used in these programs include those at the Center for Integrated Electronics, the Focus Center for Interconnects, the Center for Advanced Interconnect Systems Technologies, the electron microprobe and electron microscope facilities, accelerators at the University at Albany, the National Synchrotron Light Source at Brookhaven National Laboratory, and the Stanford Synchrotron Radiation Laboratory.

**Educational Research and Development in Physics**

Rensselaer’s physics education group pioneered the “studio” approach to physics instruction. The defining characteristics of studio physics classes are integrated lecture/laboratory form, a reduction in lecture time, a technology-enhanced learning environment, collaborative group work, and a high level of faculty-student interaction. The studio physics environment employs activities, computer tools, and multimedia materials that allow students to participate in their own learning and to construct their own scientific knowledge. Allowing students to learn directly from their interactions with the physical world through “hands-on” activities is a high priority. Students may participate in programs of the educational development group to fulfill thesis requirements for the M.S. degree.

**Particle Physics**

The structure of matter smaller than the atomic nucleus remains one of nature’s puzzles. Studies of unusual states of matter, exotic particles, provide unique insights into the fundamental properties of hadrons.

Experiments are underway at Brookhaven National Laboratory and the Thomas Jefferson National Accelerator Facility (JLAB). These experiments examine the properties of the proton and its excited states, and identify gluonic mesons. The instruments for this work are designed and constructed at Rensselaer and other collaborating institutions. A new detector is under design for the GlueX project at JLAB.

**Optical Physics**

Research in optical physics is directed toward developing new optical materials and devices. A wide range of experimental techniques is used to achieve optical characterization of materials such as nanocrystalline metal and semiconductor particles in glass or in organic materials. Among them are optical absorption, luminescence, Brillouin scattering, Raman scattering, and photomodulation spectroscopies. Experimental measurements use high pressure, low temperature, and high magnetic fields to gain further understanding of the optical properties of novel materials.

Research in optical interconnects focuses on developing and testing polymer and inorganic optical waveguides to address interconnect problems that will arise as computer chips get faster.

Ultrafast photonics and optoelectronics involve the generation and detection of picosecond and femtosecond electromagnetic pulses. Of particular interest are time-resolved experiments on THz pulses. THz spectroscopy opens up novel opportunities in material characterization and information technology. A current project applies THz pulses for biophotonic imaging. Other projects deal with switching semiconductor devices at THz frequencies.

**Faculty***

**Professors**

**Adams, G.S.**—Ph.D. (Indiana University); experimental particle physics; photo reactions, hadron structure, exotic hadrons.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
Casabella, P.A.—Ph.D. (Brown University); physics education.
Hayes, T.M.—Ph.D. (Harvard University); condensed matter physics.
Jackson, S.A.—Ph.D. (Massachusetts Institute of Technology); theoretical physics (Joint appointment with Engineering).
Lu, T.M.—Ph.D. (University of Wisconsin); thin films and interfaces.
Napolitano, J.J.—Ph.D. (Stanford University); experimental nuclear and particle physics; scientific computation.
Persans, P.D.—Ph.D. (University of Chicago); spectroscopy of semiconductors; thin films; optical materials.
Roberge, W.G.—Ph.D. (Harvard University); theoretical astrophysics.
Schowalter, L.J.—Ph.D. (University of Illinois); material physics.
Schroeder, J.—Ph.D. (Catholic University of America); optical properties of solids at high pressure.
Shur, M.S.—Dr.Sc. (Ioffe Institute); semiconductor physics, ballistic transmission, terahertz radiation (Joint appointment with ECSE).
Sperber, D.—Ph.D. (Princeton University); theoretical nuclear physics.
Stoler, P.—Ph.D. (Rutgers University); particle and nuclear physics; structure of hadrons.
Wang, G.C.—Ph.D. (University of Wisconsin); physics of surfaces, interfaces, and nanostructures.
Whittet, D.C.B.—Ph.D. (St. Andrews University); astrophysics; observational astronomy; interstellar dust; origins of life.
Zhang, X.-C.—Ph.D. (Brown University); ultrafast optics, photonic, optoelectronic and terahertz science and technology (Joint appointment with ECSE).

Associate Professor
Newberg, H.J.—Ph.D. (University of California, Berkeley); astrophysics.

Assistant Professors
Kersting, R.—Ph.D. (University of Aachen); optical physics and terahertz radiation.
Korniss, G.—Ph.D. (Virginia Polytechnic Institute); theoretical and computational physics.
Nayak, S.—Ph.D. (Jawaharlal Nehru University); theoretical physics and first principle calculations.
Wilke, I.—Ph.D. (Swiss Federal Institute of Technology); ultrafast optics, photonic, optoelectronic and terahertz science and technology.

Institute Professor
Giaever, I.—Ph.D. (Rensselaer Polytechnic Institute); biological physics.

Clinical Professor
Washington, M.A.—Ph.D. (New York University); photonics.

Clinical Associate Professor
Bedrosian, G.—Ph.D. (California Institute of Technology, Pasadena); educational physics; electromagnetic analysis.
McIntyre, C.R.—Ph.D. (Massachusetts Institute of Technology); semiconductor materials.

Visiting Professor
Ohanian, H.—Ph.D. (Princeton University); gravitation and general relativity.

Adjunct Professors
Dwyer, S.—Ph.D. (Rensselaer Polytechnic Institute); surface physics, tribology, physics education.
Haus, J.—Ph.D. (Catholic University); quantum optics, statistical mechanics.
Hudspeth, Q.—Ph.D. (University of Florida); physics education, thin film electronic transport, physics of surfaces.
Taiuti, M.—Ph.D. (Dottore di Ricerca in Fisica); nuclear and particle physics.
Weygand, D.—Ph.D. (Syracuse University); nuclear and particle physics.

Research Professors
Lee, S.—Ph.D. (University of Michigan); condensed matter.
Slack, G.—Ph.D. (Cornell University); electronic materials and thermoelectrics.

Research Associate Professor
Lu, J.—Ph.D. (Technical University of Munich); electronic materials.

Research Assistant Professors
Cummings, J.—Ph.D. (Rice University); experimental nuclear and particle physics.
Senkevich, J.—Ph.D. (Rensselaer Polytechnic Institute); physics and chemistry of surfaces and interfaces, self-assembled chemistry and ultrathin films.

Visiting Scientists
Cummings, K.—Ph.D. (SUNY Albany); educational physics.
Edelstein, W.—Ph.D. (Harvard University); magnetic resonance imaging basic sciences and applications.
Schujman, S.—Ph.D. (Instituto Balsiero, Argentina); thin film solar cells.
Wagner, D.J.—Ph.D. (Vanderbilt University); educational physics.

Undergraduate Programs

Undergraduate students begin with core curriculum courses that teach basic scientific principles and develop skills in problem solving, scientific thinking, and clear oral and written expression. Students also choose from a broad range of advanced courses in the Department of Physics, Applied Physics, and Astronomy and in other science and engineering departments depending upon their individual career goals.

Baccalaureate Programs
Rensselaer offers two undergraduate programs in physics, one leading to the B.S. in Physics and the other to the B.S. in Applied Physics. Students in the applied physics program must declare a concentration in a specific technological area, in which they take at least four elective courses.

Physics Curriculum

First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1100</td>
<td>Physics I ............................................4</td>
<td>PHYS-1200</td>
<td>Physics II ............................................4</td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .............................................4</td>
<td>MATH-1020</td>
<td>Calculus II .............................................4</td>
</tr>
<tr>
<td>CHEM-1100</td>
<td>Chemistry 1 .............................................4</td>
<td></td>
<td>Science Option .............................................4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective ............................3–4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective ............................3–4</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-2100</td>
<td>Intro. to Methods of Theoretical Physics .............4</td>
<td>PHYS-2350</td>
<td>Experimental Physics ....................................4</td>
</tr>
<tr>
<td>MATH-2010</td>
<td>Multivariable Calculus and Matrix Algebra .............4</td>
<td>MATH-2400</td>
<td>Intro. to Differential Equations .....................4</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I ......................................4</td>
<td></td>
<td>Elective ..................................................4</td>
</tr>
<tr>
<td></td>
<td>Elective 5 .............................................3–4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective 5 ..........................3–4</td>
</tr>
</tbody>
</table>

1 A Senior Project is required, which consists of a research course, cooperative assignment, or prior research project approval.
2 CHEM-1500 may be substituted for CHEM-1100.
3 A total of 24 credits in Hum. or Soc. Sci. electives is required.
4 Course chosen from Astronomy, Biology, Chemistry, Computer Science, Geology, or Mathematics.
5 Students with little or no electronics experience are encouraged to take ENGR-1310, a one-credit laboratory course, in addition to this four-credit elective.
### Applied Physics Curriculum

**First Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>PHYS-1100</td>
<td>Physics I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-1010</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CHEM-1100</td>
<td>Chemistry I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
<tr>
<td>Spring</td>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-1020</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
</tbody>
</table>

**Second Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>PHYS-2100</td>
<td>Intro. to Methods of Theoretical</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-2010</td>
<td>Multivariable Calculus and Matrix</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
<tr>
<td>Spring</td>
<td>PHYS-2350</td>
<td>Experimental Physics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>PHYS-2330</td>
<td>Intermediate Mechanics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-2510</td>
<td>Quantum Physics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
<tr>
<td>Spring</td>
<td>PHYS-4210</td>
<td>Electromagnetic Theory</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-4100</td>
<td>Intro. to Quantum Mechanics</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PHYS-4420</td>
<td>Thermodynamics and Statistical</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
<tr>
<td>Spring</td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td>3–4</td>
</tr>
</tbody>
</table>

---

1. A Senior Project is required, which consists of a research course, cooperative assignment, or prior research project approval.
2. CHEM-1500 may be substituted for CHEM-1100.
3. A total of 24 credits in Hum. or Soc. Sci. electives is required.
4. Course chosen from Astronomy, Biology, Chemistry, Computer Science, Geology, or Mathematics.
5. Students with little or no electronics experience are encouraged to take ENGR-1310, a one-credit laboratory course, in addition to this four-credit elective.
6. Technical electives are to be selected with the aid of an adviser in order to create a concentration in an appropriate applied physics field.
Concentrations
The applied physics program requires a concentration of four technical courses that focuses on a specific technological area. Possible concentrations include, but are not limited to optical physics, microelectronics, semiconductor physics, optoelectronics, geophysics, biophysics, computation applied physics, and environmental physics. Two such concentrations are illustrated below:

**Optical Physics**—A concentration in optical physics might include four courses from the following list:
- PHYS-2620 Fundamentals of Optics
- PHYS-4630 Lasers and Optical Systems
- PHYS-4720 Solid-State Physics
- PHYS-4640 Optical Communications and Integrated Optics

**Microelectronics**—A concentration in microelectronics might include courses from the following list:
- ECSE-2050 Analog Electronics and Circuits
- ECSE-4220 VLSI Design
- ECSE-2210 Microelectronics Technology
- ECSE-4250 Integrated Circuit Processes and Design

**Electives**
Physics or applied physics majors planning to continue on to graduate studies in these areas should take some combination of advanced physics courses to prepare for these studies. These courses should be chosen from the following undergraduate- and graduate-level courses:
- PHYS-4720 Solid-State Physics
- PHYS-4630 Lasers and Optical Systems
- PHYS-4620 Particles and Nuclei
- ASTR-4220 Astrophysics
- ASTR-4240 Gravitation and Cosmology
- PHYS-6510 Quantum Mechanics I
- PHYS-6520 Quantum Mechanics II
- PHYS-6310 Advanced Mechanics
- PHYS-6110 Methods in Theoretical Physics
- ASTR-4220 Astrophysics
- ASTR-4240 Gravitation and Cosmology

Students planning on graduate work in astronomy or astrophysics are urged to choose electives from the above list, as well as include the following:
- ASTR-2050 Intro. to Astr. and Astrophysics
- ASTR-4120 Observational Astronomy
- PHYS-6100 Methods in Theoretical Physics
- ASTR-4220 Astrophysics
- ASTR-4240 Gravitation and Cosmology

**Minor Programs**
The Department of Physics, Applied Physics, and Astronomy offers the following minors:

**Physics**
Students not majoring in physics may minor in this subject by taking at least 16 credit hours of physics courses (coded PHYS) at the 2000 level or higher.

**Astronomy**
To complete an astronomy minor, a student should take PHYS-2510, ASTR-2050, and two of the following courses: ASTR-4120, ASTR-4510, or ASTR-4960.

**Astrophysics**
This minor is available to students majoring in physics and planning on graduate study in astronomy or astrophysics. To complete this minor, a student should take PHYS-2510, ASTR-4220, at least one four-credit research project in astrophysics, and at least three semesters of the one-credit ASTR-4900.

---

7 Students cannot receive credit for ECSE-4250 and MTLE-4160
Astrobiology
This multidisciplinary minor is open to students majoring in physics or in other disciplines. To complete this minor, a student must take a minimum of 16 credits of course work in this field. These courses must include four credits each of ASTR-4510 and ISCI-4500, and two semesters of the one-credit ISCI-4510. Two additional courses outside the major field of study must also be selected from the following:

- ENVE-2110 Intro. to Environmental Engineering
- BIOL-4320 Geomicrobiology
- BIOL-4440 Microbial Ecology
- BIOL-4620 Molecular Biology
- BIOL-4760 Molecular Biochemistry I
- BCBP-4810 Biological Spectroscopy
- BCBP-4860 Protein and Nucleic Acid Structure
- CHEM-2250 Organic Chemistry I
- CHEM-4810 Chemistry of the Environment
- ERTH-4070 Sedimentology
- ERTH-4540 Organic Geochemistry
- ASTR-2050 Intro. to Astr. and Astrophysics

The requirement that two selected courses must be outside the major is reduced to one in the case of a double major, provided that both majors are in the primary relevant areas of study (i.e., biology, chemistry, geology, and physics).

Dual Major Programs
Students may form a dual major in physics and any other degree program within the School of Science. In these cases, the program will satisfy the requirements of both degrees. In addition, a dual major in physics and philosophy is available by satisfying the physics requirements and pursuing 10 philosophy courses.

Accelerated Programs
Students may generally select, in their junior year, to follow a five-year B.S.-M.S. program. These students receive the B.S. in physics and the M.S. in either physics or another science or engineering discipline.

Graduate Programs
Graduate students develop flexible individual programs of study and research in one or more of the available research areas. The department offers both the M.S. and Ph.D. degrees in physics.

Master’s Programs
Completion of the M.S. requires 30 credits of graduate work, including a minimum of 21 credits in course work. Course work should meet the needs of the individual student, but must include PHYS-6510 and two of the following four courses: PHYS-6520, PHYS-6310, PHYS-6110, and PHYS-6410. The master’s degree also requires some credits of research, which may culminate in a formally presented thesis (six to nine credits) or a research project (three credits). Some teaching experience is required for the degree.

Doctoral Programs
Ninety credits beyond the bachelor’s degree or 60 credits beyond the M.S. are required, including credits for original research culminating in a formally presented thesis. A manuscript on the thesis research should be prepared for publication.

Admission to the Ph.D. program is granted only upon passing a written qualifying examination at the beginning of the third semester of Rensselaer graduate work. The advanced undergraduate-level exam is given in two parts: 1) Mechanics and Electrodynamics and 2) Quantum Mechanics, Thermodynamics, and Introduction to Statistical Mechanics. The examination is given twice annually in August and January.

Doctoral requirements do not state a minimum number of course credits. However, students must take the basic core of six courses including PHYS-6310, PHYS-6510 and PHYS-6520, PHYS-6590, PHYS-
6110, and PHYS-6410. Students are expected to obtain a grade of at least B in each of these courses. In addition to the above sequence of core courses, there are the following doctoral course requirement: 1) one graduate 6000-level course in the area of research specialization; 2) three courses related to the student's educational needs as authorized by the student's research adviser. Note: PHYS-6530 is strongly recommended for all students. (All theory students should take this course). There are special requirements for students specializing in astrophysics and biophysics.

Once students have chosen a Ph.D. project and assembled a committee, they will present a brief written thesis proposal to the committee and orally defend it. In the oral exam, members of the committee question students specifically on the planned research and more generally on the physics related to that research. This candidacy exam is normally taken at the end of the third year.

Some teaching experience is also required for the Ph.D. degree.

**Course Descriptions**

Courses directly related to all Physics, Applied Physics, and Astronomy curricula are described in the Course Description section of this catalog under the department codes PHYS or ASTR.

**Computer Science at Hartford**

**Chair:** James C. McKim, Jr. (Interim)

**Master of Science in Computer Science**

Applicants are assumed to have knowledge of computer concepts and programming in a high-level language (e.g., C, Pascal). To receive the Master of Science degree in Computer Science, students must earn a minimum of 30 credit hours in computer science or engineering courses and satisfy the following requirements:

**Plan of Study**

Each student completes a plan of study in consultation with his or her adviser. This plan will include required immigration courses (if any), two core courses, elective courses, and program completion. At least two of the elective courses should pertain to a specific area, which reflects the student's professional or academic interest.

**Immigration Courses**

Depending on academic background and professional experience, some students may be required to begin their studies with one or more prerequisite “immigration” course(s) beyond the standard 30 credit hours. The immigration courses are:

- CISH-4961 Introduction to Computer Programming
- CISH-4010 Discrete Mathematics and Computer Theory
- CISH-4020 Object Structures
- CISH-4030 Structured Computer Architecture

Students with two or more immigration courses as prerequisites may be admitted conditionally. Since these are the equivalent of undergraduate courses, students are expected to achieve a grade of “B” or better in each course. Achievement below this level is cause for reexamination of admission. In addition, these immigration courses will not enter into the calculation of a student's GPA for graduation.
Core Courses
Each plan of study will contain the following two courses:

CSCI-4210 Operating Systems
CSCI-6050 Computability and Complexity

Elective Courses
To provide some breadth to the plan of study, each student will take one course from each of the following three groups:

- Hardware systems (e.g., networking, computer architecture)
- Software systems (e.g., software engineering, object oriented design)
- Applications (e.g., database management, software engineering management)

With the exception of the immigration courses, all courses with the designation CISH or CSCI and most designated ECSE may be used as electives for the degree.

Advanced Courses
At least eighteen credit hours must be at the “advanced” level. All courses with suffix numbers 6000–6990 fall into this category. These courses may include special topics courses which are offered under CISH, CSCI-6960, or ECSE-6960.

After completing course work in a particular area, students may elect to complete a six credit master’s project (CISH-6980 or CSCI-6980) or thesis (CISH-6990 or CSCI-6990) in that area.

Program Completion
Students will complete their program of study via one of two paths:

Applied Path
CISH-6960 Research Methods
CISH-6900 Computer Science Seminar

Theory Path
A Theory Course
Master’s Thesis/Project

For More Information
Information concerning the computer science programs at Rensselaer at Hartford may be obtained by contacting James C. McKim, Jr. at (860) 548-2458, (800) 290-7637 x 2458, or e-mail: jcm@rh.edu, or visit www.rh.edu/does/.

Computer Science Graduate Certificate Programs
The Computer Science Graduate Certificate Programs are designed with a selective focus and require that a student successfully complete four graduate courses (12 credit hours of which nine must be in residence), with an average grade of “B” or better, in a specific area of computer science. Credits earned in Graduate Certificates may be subsequently applied toward a Master of Science degree as electives with the adviser’s approval. Additional information can be obtained from the appropriate program coordinator listed for the six Graduate Certificates below.

Bioinformatics
BIOL-6960 Bioinformatics I
BIOL-6960 Bioinformatics II
CSCI-4380 Database Systems
   Approved Elective
Program coordinator: Susan Smith, e-mail: salers2@rpi.edu

**Computer Network Communications**
ECSE-4670 Computer Communication Networks
Select any three of the following courses:
CISH-6210 Computer Network Analysis and Design
CISH-6220 LANs, MANs, and Internetworking
CISH-6230 Network Management
CISH-6960 Cryptography and Network Security
ECSE-6660 Broadband Networks
Program coordinator: Roger H. Brown, (860) 548-2462, (800) 290-7637 x 2462, or e-mail: rhb@rh.edu

**Database Systems**
CSCI-4380 Database Systems
CSCI-6460 Advanced Database Management Topics
CISH-6110 Object Oriented Database Systems
CISH-6120 Distributed Database Systems or
CSCI-6470 Database Systems for Engineering Applications
Program coordinator: Timothy O. Martyn, (860) 548-2460, (800) 290-7637 x 2460, or e-mail: martyn@rh.edu

**Graphical User Interface**
COMM-6420 Foundations of Human/Computer Interaction
CISH-6320 GUI Building
CISH-6010 Object Oriented Programming and Design
   Approved Elective
Program coordinator: James C. McKim, (860) 548-2458, (800)290-7637 x 2458, or e-mail: jcm@rh.edu

**Information Systems**
ECSE-4670 Computer Communication Networks
CSCI-4380 Database Systems
COMM-6420 Foundations of Human/Computer Interaction
CISH-4020 Object Structures or
ECSE-6770 Software Engineering I or
CISH-6010 Object Oriented Programming and Design
Program coordinator: Timothy J. Hartley, (860) 548-7928, (800) 290-7637 x 7928, or e-mail: hartley@rh.edu

**Software Engineering**
   Required
ECSE-6770 Software Engineering I
CISH-6050 Software Engineering Management
Electives (Select any two of the following)
CISH-6010 Object Oriented Programming and Design
CISH-6510 Web Application Design and Development
CISH-6320 GUI Building
ECSE-6780 Software Engineering II
Interdisciplinary Programs and Research

Rensselaer’s commitment to providing opportunities for interdisciplinary education is especially apparent within the School of Science. After all, the successful pursuit of almost any Institute field of study requires a strong background in one or more of the sciences. Furthermore, the various scientific disciplines overlap in many ways, just an example of which are the mathematics-based fields of chemistry and physics. The School of Science offers an impressive array of unique programs that cross not only scientific disciplines, but also disciplines within other Institute Schools.

The special interdisciplinary opportunities administered by the School of Science allow students to develop a breadth and depth of knowledge in multiple disciplines, and include both degree and research programs. By nature, these programs are highly flexible and often involve working in teams with faculty and students representing multiple disciplines.

Additional interdisciplinary programs available at Rensselaer are outlined within the catalog section of the associated Institute school or division.

Applied Science

The School of Science offers a Master of Science in Applied Science, which is a professional, nonthesis degree that prepares graduates who have traditional discipline-oriented backgrounds to function more effectively in industrial, governmental, or other interdisciplinary occupations. Its intention is to help working professionals upgrade their technical expertise and cross boundaries among disciplines. In addition to extensive science offerings, students may take applicable courses in other schools such as Management, Engineering, or Humanities and Social Sciences.

Students entering the Master of Science in Applied Science program are subject to Rensselaer’s general admission requirements. All programs require 30 credit hours for completion of the degree. At least half of those courses must be at the 6000 level. Within these 30 hours, a number of concentration options are also available. At least 15 hours must be in courses within the School of Science, and include some 6000 level courses.

Some concentration examples include: analytical and environmental chemistry, applied groundwater science, biochemistry/biophysics, bioinformatics, chemistry and entrepreneurship, database management systems, microelectronics manufacturing, optimization and statistics, parallel and scientific computation, photonics, polymer science and engineering, and software engineering. In addition, further combinations of courses leading to the Master of Science in Applied Science are developed as additional needs for interdisciplinary education are identified.

A typical Master of Science in Applied Science curriculum consists of:

- Two to four core courses that establish the basis for advanced study in an area of specialization
- Two to four specialization courses that are fundamental to an area of specialization
- Two to six elective courses that allow students to focus in a particular area within their specialization and gain skills intersecting their technical field with other disciplines.
Biochemistry and Biophysics

**Director, Undergraduate Degree Program:** Joyce J. Diwan

**Director, Graduate Degree Program:** Jane F. Koretz

Biochemistry and biophysics are closely related fields. Biochemistry focuses on the interconversion of compounds in the many complex reactions of life, on the mechanisms whereby enzymes catalyze and regulate these reactions, and the function and structure of the molecular components of living organisms. Biophysics is principally concerned with processes of energy conversion, information transmission, and the structure and properties of materials in biological systems, as explored with methods of physics. Biochemical and biophysical research is advancing the frontiers of research in the basic life sciences and making possible advances in more applied fields such as medicine and agriculture. For example, in the pharmaceutical industry, elucidating mechanisms of drug action and devising new ways of dealing with diseases has increasingly depended on application of knowledge and techniques of biochemistry and biophysics.

Rensselaer’s biochemistry and biophysics undergraduate curriculum includes thorough grounding in mathematics, chemistry, and physics, along with modern biochemistry, biophysics, and molecular-level biology. Advanced biochemistry and biophysics courses, many of which are jointly taught by biology and chemistry faculty, impart knowledge and training in cutting-edge research approaches. Students following this curriculum are thus exceptionally well prepared for graduate school and to become desirable prospective employees in various sectors of the biotechnology industry. The curriculum also provides an excellent background for students planning careers in medicine. While rigorous, the undergraduate curriculum offers sufficient flexibility and course choices to allow students to tailor their education to particular career paths. Most students pursue undergraduate research in faculty laboratories. Many seek industrial experience through Rensselaer’s Cooperative Education Program, and the high degree of flexibility facilitates fitting a co-op experience into the degree program.

The master’s degree program primarily prepares students for jobs in biotechnology, pharmaceuticals, and other related industry sectors. It is also well suited to students wishing to upgrade their skills while employed in industry. The program may also be attractive to students wishing to obtain an M.S. degree before proceeding to professional study in medicine, veterinary science, dentistry, etc. Those with a B.S. degree in a field not closely related to modern biological science who wish to enter into a doctoral program at Rensselaer or elsewhere may also benefit from the program.

**Research Innovations and Initiatives**

Biophysical research at Rensselaer includes the study of areas as diverse as focusing processes of the eye, electrical impedance assays of cell motility, photosynthesis, cellular bioengineering, biofluid mechanics, and electric current computed tomography. A variety of approaches, including molecular modeling, spectroscopic probes, de novo design and chemical synthesis of unnatural proteins, and molecular biology are being used to study protein structure. Biochemical research includes the application of chromatography to large-scale purification of biological macromolecules, biosensors, prebiotic chemistry, biochemical signaling, bioanalytical chemistry, and the catalysis and mechanisms of protein folding.

**Faculty**

The science and engineering faculty members of the Center for Biophysics listed below provide a variety of research opportunities for undergraduate and graduate students enrolled in the Biochemistry and Biophysics degree programs. Faculty members from the Biology and Chemistry Departments who are involved in the teaching of biochemistry and biophysics courses are designated with an asterisk (*).

**Biology:** C. Bystroff,* J. Diwan,* J.F. Koretz,* R.E. Palazzo,* R.H. Parsons, H. Roy,* J.C. Salerno*

**Biomedical Engineering:** R. Bizios, N. DePaola, J.C. Newell

Mathematical Sciences: M.H. Holmes, D. Isaacson

Chemical Engineering: G. Belfort, S.M. Cramer, J.S. Dordick

School of Science: I. Giaever, C.R. Keese

Undergraduate Program

Biochemistry and Biophysics Curriculum

First Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010 Calculus I   4</td>
<td>MATH-1020 Calculus II 4</td>
</tr>
<tr>
<td>CHEM-1100 Chemistry I   4</td>
<td>CHEM-1200 Chemistry II 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>BIOL-2120 Intro. Cell and Molec. Biology 4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>Hum. or Soc. Sci. Elective 4</td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2250 Organic Chemistry I 4</td>
<td>CHEM-2260 Organic Chemistry II 4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I 4</td>
<td>PHYS-1200 Physics II 4</td>
</tr>
<tr>
<td>Quantitative Option 4</td>
<td>BIOL-4620 Molecular Biology 4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>Hum. or Soc. Sci. Elective 4</td>
</tr>
</tbody>
</table>

Third Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCBP-4760 Molecular Biochemistry I 4</td>
<td>BCBP-4770 Molecular Biochemistry II 4</td>
</tr>
<tr>
<td>CHEM-2440 Physical Chem. for Life Sci. 4</td>
<td>Elective 4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective 4</td>
<td>Hum. or Soc. Sci. Elective 4</td>
</tr>
</tbody>
</table>

Fourth Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molec. Biophysics Module 4</td>
<td>Molec. Biophysics Module 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>Elective 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>Elective 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>Elective 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>Elective 4</td>
</tr>
<tr>
<td>Elective 4</td>
<td>Elective 4</td>
</tr>
</tbody>
</table>

The above curriculum requires 128 total credit hours, with Humanities and Social Science courses making up at least 24 of those credits.

By shifting electives, the Molecular Biophysics Modules, the Quantitative Option, and the Laboratory Option course may be taken in semesters other than those shown above. Courses that satisfy the Molecular Biophysics Modules, Quantitative Option, and Laboratory Option are shown below.

Molecular Biophysics Modules (Choose 2)

| BCBP-4810 Biological Spectroscopy | BCBP-4860 Protein and Nucleic Acid Structure |
| BCBP-4210 Biophysical Methods | BCBP-4790 Protein Chemistry |
| BCBP-4310 Genetic Engineering | BCBP-4870 Crystallographic Analysis of Protein |
| BCBP-4780 Protein Folding | Structure |

1 Molecular Biology may be taken in the spring of the second or third year.

2 Students may substitute CHEM-4450 plus CHEM-4460
Quantitative Option (Choose 1)

CSCI-1100  Computer Science I
CSCI-1010  Intro. to Computer Programming
MATH-2010  Multivariable Calculus and Matrix Algebra

MATH-2400  Intro. to Differential Equations
MATH-4720  Mathematics in Medicine and Biology

Laboratory Option (Choose 1)

BCBP-4710  Biochemistry Laboratory

BIOL-2500  Genetics and Evolution
BIOL-4260  Cell Biology
BIOL-4420  Introductory Immunology
BCBP-4710  Biochemistry Laboratory
BIOL-4270  Human Physiology I
BCBP-4860  Protein and Nucleic Acid Structure
BCBP-2900  Research in Biochemistry and Biophysics
BCBP-4790  Protein Chemistry
BCBP-2900  Research in Biochemistry and Biophysics
BCBP-4790  Protein Chemistry
BCBP-2900  Research in Biochemistry and Biophysics
BCBP-4790  Protein Chemistry

Recommended Electives

MATH-2010  Multivariable Calculus and Matrix Algebra
MATH-2400  Intro. to Differential Equations
MATH-4720  Mathematics in Medicine and Biology
CSCI-1100  Computer Science I
BIOL-2310  Microbiology
BIOL-2500  Genetics and Evolution
BIOL-4260  Cell Biology
BIOL-4420  Introductory Immunology
BIOL-4510  Molecular Genetics
BIOL-4540  Bioinformatics I
BIOL-4550  Bioinformatics II
BIOL-4510  Molecular Genetics
BIOL-4540  Bioinformatics I
BIOL-4550  Bioinformatics II
BCBP-2900  Research in Biochemistry and Biophysics
BCBP-2930  Out of Class Exp. in Biochemistry and Biophysics
BCBP-2940  Readings in Biochemistry and Biophysics
BCBP-2990  Research Thesis
BCBP-4210  Biophysical Methods
BCBP-4310  Genetic Engineering
BCBP-4780  Protein Folding
BCBP-4810  Biological Spectroscopy
BCBP-4860  Protein and Nucleic Acid Structure
BCBP-4870  Crystallographic Analysis of Protein Structure
CHEM-2150  Equilibrium Chemistry and Quantitative Analysis
CHEM-4200  Medicinal Chemistry
CHEM-4310  Bioorganic Mechanisms
CHEM-4330  Drug Discovery
CHEM-4520  Chemical Information
CHEM-4620  Introduction to Polymer Chemistry
CHEM-4640  Polymer Science Laboratory
CHEM-4810  Chemistry of the Environment
PHYS-2510  Quantum Physics
DSES-4140  Statistical Analysis

Depending on immediate and long-range goals, students whose plans include one or more of the following career paths are advised to consider including the courses listed below among their module, option, or free elective choices. Students should consult their advisers when selecting courses from these lists.

Graduate School—Biochemistry

CSCI-1100  Computer Science I
BIOL-2500  Genetics and Evolution
BIOL-4260  Cell Biology
BIOL-4510  Molecular Genetics
BIOL-4720  Molecular Biology Laboratory
BCBP-2900  Research in Biochem./Biophys.

BCBP-2900  Research Thesis
BCBP-4710  Biochemistry Laboratory
BCBP-4780  Protein Folding
BCBP-4790  Protein Chemistry
BCBP-4860  Protein and Nucleic Acid Structures
CHEM-4310  Bioorganic Mechanisms
### Graduate School—Biophysics

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2010</td>
<td>Multivariable Calc. and Matrix Algebra</td>
<td>BCBP-2990</td>
<td>Research Thesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-2400</td>
<td>Intro. to Differential Equations</td>
<td>BCBP-4210</td>
<td>Biophysical Methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-4720</td>
<td>Math. in Medicine and Biology</td>
<td>BCBP-4810</td>
<td>Biological Spectroscopy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>BCBP-4870</td>
<td>Crystallographic Analysis of Protein</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCBP-2900</td>
<td>Research in Biochemistry/Biophysics</td>
<td></td>
<td>Structure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Biotechnology Industry—Research

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>BCBP-2990</td>
<td>Research Thesis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-2310</td>
<td>Microbiology</td>
<td>BCBP-4310</td>
<td>Genetic Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-2500</td>
<td>Genetics and Evolution</td>
<td>CHEM-4300</td>
<td>Medicinal Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4540</td>
<td>Bioinformatics I</td>
<td>CHEM-4330</td>
<td>Drug Discovery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4720</td>
<td>Molecular Biology Laboratory</td>
<td>CHEM-4620</td>
<td>Intro. to Polymer Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCBP-2900</td>
<td>Research in Biochem./Biophys.</td>
<td>CHME-4430</td>
<td>Intro. Biochemical Engineering</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Biotechnology Industry—Management/Law

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON-1200</td>
<td>Intro. Economics</td>
<td>BCBP-4310</td>
<td>Genetic Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECON-2010</td>
<td>Managerial Economics</td>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>MGMT-1100</td>
<td>Intro. Management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-2310</td>
<td>Microbiology</td>
<td>DSES-4140</td>
<td>Statistical Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4310</td>
<td>Industrial Microbiology</td>
<td></td>
<td>Other courses of economics and management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Medical/Dental School

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-2500</td>
<td>Genetics and Evolution</td>
<td>BIOL-4420</td>
<td>Introductory Immunology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4270</td>
<td>Human Physiology I</td>
<td>BIOL-4260</td>
<td>Cell Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4280</td>
<td>Human Physiology II</td>
<td>CHEM-4300</td>
<td>Medicinal Chemistry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-2310</td>
<td>Microbiology</td>
<td></td>
<td>Other courses in biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-2410</td>
<td>Embryology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Bioinformation

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2010</td>
<td>Multivariable Calc. and Matrix Algebra</td>
<td>BIOL-4540</td>
<td>Bioinformatics I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
<td>BIOL-4550</td>
<td>Bioinformatics II</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II</td>
<td>BCBP-4210</td>
<td>Biophysical Methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSCI-2300</td>
<td>Data Structures and Algorithms</td>
<td>BCBP-4310</td>
<td>Genetic Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIOL-4510</td>
<td>Molecular Genetics</td>
<td>BCBP-4860</td>
<td>Protein and Nucleic Acid Structure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Minor Programs

Students majoring in chemistry, biology, bioinformatics, or chemical engineering may obtain a minor in either biochemistry or biophysics by completing the courses listed below. Since different essential courses are included in the requirements of each major, the minor requirements vary for different majors.

#### Biochemistry Minor for Chemistry Majors

Students must complete BIOL-2120, BCBP-4770, and two of the following: BCBP-4710, BIOL-4260, BIOL-4620, BCBP-4860, BCBP-4310, BCBP-4780, BCBP-4790, CHEM-4310.

#### Biophysics Minor for Chemistry Majors

Students must complete BIOL-2120, BCBP-4770, and two of the following: MATH-2400, MATH-4720, BIOL-4270, BCBP-4210, BCBP-4810, BCBP-4870, PHYS-2510.
Biochemistry Minor for Biology and Bioinformatics Majors
Students must complete BCBP-4770, CHEM-2440, and two of the following: BCBP-4710, BIOL-4260, BCBP-4860, BCBP-4780, BCBP-4790, BCBP-4310, CHEM-4310.

Biophysics Minor for Biology and Bioinformatics Majors
Students must complete BCBP-4770, CHEM-2440, and two of the following: MATH-2400, MATH-4720, BIOL-4270, BCBP-4210, BCBP-4810, BCBP-4870, PHYS-2510.

Biochemistry Minor for Chemical Engineering Majors
Students must complete BIOL-2120, BCBP-4760, BCBP-4770, and one of the following: BCBP-4710, BIOL-4620, BCBP-4790, BCBP-4780, BCBP-4860, BCBP-4310, CHEM-4310.

Biophysics Minor for Chemical Engineering Majors
Students must complete BIOL-2120, BCBP-4760, BCBP-4770, and one of the following: MATH-4720, BCBP-4210, BCBP-4810, BCBP-4870.

Graduate Programs
Both the Master of Science and Master of Science in Applied Science degrees are available within the Biochemistry and Biophysics program. Each requires a total of 30 credit hours.

For the Master of Science degree in Biochemistry and Biophysics, 15 credits must be in courses at the 6000–6999 level. In addition, six to nine credits must be in research. Students must either have had in their undergraduate study or must include in their M.S. plan of study three of the molecular biophysics module courses listed above in the undergraduate curriculum, or their graduate equivalents. A thesis based on original work is required.

The Master of Science in Applied Science degree program features the possibility of combining master's level cooperative education participation or equivalent industrial experience, with course work for the degree in biochemistry and biophysics.

Course Descriptions
Courses of interest to Biochemistry and Biophysics students are described in the Course Description section of this catalog under the codes BIOL, BCBP, and CHEM. Course selections should be discussed with the student’s adviser.

Bioinformatics and Molecular Biology

Director, Undergraduate and Graduate Degree Programs: John C. Salerno
Program Home Page: http://www.rpi.edu/dept/science/www/Ugrad_options/Bioinformatics

Revolutions in biotechnology and information technology are changing the world. Advances in molecular genetics, coupled with improved capability in robotics, computer science, and other technologies, have made mass sequencing of genetic material a part of the scientific landscape. Previously, growing sequence databases had been compiled one gene at a time by individual research laboratories. This cottage industry approach is still part of the effort, but numerous genome-sequencing projects have produced the entire sequences of viruses, bacteria, and increasingly complex eukaryotic organisms. The complete human genome with its 109 base pairs is now complete.

The enormous treasure trove of information that the sequence databases and their smaller structural counterparts represent is a priceless resource. Applications include the identification of targets for drug discovery, the study of structural and functional relationships, and work on molecular evolution. Timely
advances in computer science have made the storage, organization, and utilization of these very large data collections possible.

Bioinformatics approaches incorporate expertise from the biological sciences, computer science, and mathematics. Allied computational approaches using chemical and physical methods are also of widespread interest. Rensselaer’s bioinformatics and molecular biology undergraduate curriculum includes training in mathematics, chemistry, and physics. At the program’s core are courses in the theory and practice of bioinformatics that deal with topics such as database design and search algorithms, sequence alignment, sequence analysis, and molecular modeling. The core includes a molecular biology sequence and training in drug discovery.

The curriculum is extremely flexible, allowing for dual majors with several other disciplines including computer science. Advanced courses are available through the biology program and the biochemistry and biophysics program, including a strong set of advanced laboratory courses. Through appropriate elective selection, students planning careers as molecular biologists with a computational background or as fully trained computer scientists with a knowledge of biological sciences can adapt the program to their needs.

There are extensive opportunities to pursue undergraduate research in faculty laboratories. The bioinformatics and molecular biology program also serves as an excellent premedical curriculum.

**Research Innovations and Initiatives**

Bioinformatics research at Rensselaer includes the design and application of algorithms for sequence database searching, sequence alignment, and sequence analysis, molecular modeling, and allied areas in computational chemistry and simulation of biological processes. Closely related research in molecular genetics and biochemistry provides concrete applications for graduate and undergraduate students. A diverse group of agencies including NIH, NSF, the American Diabetes Association, and NASA fund this work. Research projects range from drug discovery, enzymology, signal transduction, protein structure, and protein folding to studies on environmental adaptations of microorganisms.

**Faculty**

**Biology:** C. Bystroff, D. Crone, J. Diwan, J.F. Koretz, J.C. Salerno, S.M.E. Smith

**Chemistry:** C.M. Breneman, W. Colon, M. Wentland

**Computer and Information Science at Hartford:** T. O. Martyn

**Computer Science:** B.K. Szymanski, M.Zaki

**Decision Sciences and Engineering Systems:** M.J. Embrechts

**Mathematical Sciences:** M. Zuker

**Undergraduate Programs**

**Bioinformatics and Molecular Biology Undergraduate Curriculum**

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH-1010</td>
<td>Calculus I .........................................4</td>
<td>MATH-1020</td>
<td>Calculus II .........................................4</td>
</tr>
<tr>
<td>CHEM-1100</td>
<td>Chem. I .............................................4</td>
<td>CHEM-1200</td>
<td>Chem. II .............................................4</td>
</tr>
<tr>
<td></td>
<td>Elective .............................................4</td>
<td>BIOL-2120</td>
<td>Intro. Cell and Molec. Biol.................4</td>
</tr>
<tr>
<td></td>
<td>Hum. or Soc. Sci. Elective .........................4</td>
<td></td>
<td>Hum. or Soc. Sci. Elective .................4</td>
</tr>
</tbody>
</table>
## Second Year
### Fall
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2250 Organic Chem. I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1100 Physics I</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Spring
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2260 Organic Chem. II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1200 Physics II</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-4620 Molecular Biology</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

## Third Year
### Fall
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-4760 Molec. Bioch. I</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Spring
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-4330 Drug Discovery</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-4770 Molecular Bioch. II</td>
<td>4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

## Fourth Year
### Fall
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-4540 Bioinformatics I</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-4720 Molecular Biology Lab</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

### Spring
<table>
<thead>
<tr>
<th>Course</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-4550 Bioinformatics II</td>
<td>4</td>
</tr>
<tr>
<td>BIOL-4630 Molecular Biology II</td>
<td>4</td>
</tr>
<tr>
<td>Elective</td>
<td>4</td>
</tr>
</tbody>
</table>

## Elective Recommendations
### Biochemistry
- **BCBP-4310** Genetic Engineering
- **BCBP-4810** Biological Spectroscopy
- **BCBP-4210** Biophysical Methods
- **BCBP-4860** Protein and Nucleic Acid Structure
- **BCBP-4710** Biochemistry Laboratory
- **BCBP-2900** Research in Biochemistry and Biophysics
- **BCBP-2830** Out of Class Exp. in Biochemistry and Biophysics
- **BCBP-2940** Readings in Biochemistry and Biophysics
- **BCBP-2990** Research Thesis
- **BCBP-4210** Biophysical Methods

### Biology
- **BIOL-1010** Introduction to Biology
- **BIOL-2310** Microbiology
- **BIOL-2500** Genetics and Evolution
- **BIOL-4270** Human Physiology I
- **BIOL-4280** Human Physiology II
- **BIOL-4420** Introductory Immunology
- **BIOL-4510** Molecular Genetics
- **BIOL-4740** Cell and Developmental Biology Laboratory

### Chemistry
- **CHEM-2440** Physical Chemistry for Life Sciences
- **CHEM-4300** Medicinal Chemistry
- **CHEM-4310** Bioorganic Mechanisms
- **CHEM-4450** Macroscopic Physical Chemistry
- **CHEM-4460** Microscopic Physical Chemistry
- **CHEM-4520** Chemical Information
- **CHEM-4620** Introduction to Polymer Chemistry
- **CHEM-4640** Polymer Science Laboratory
- **CHEM-4810** Chemistry of the Environment
Graduate Program

The primary goal of the master's degree program in this field is to educate students for jobs in biotechnology, pharmaceuticals, and related industry sectors. The professional Master of Science in Applied Science program with a concentration in bioinformatics is also available to those wishing to upgrade their skills while employed in industry. The Master of Science in biology with a concentration in bioinformatics may attract those desiring an M.S. degree before proceeding to professional study in medicine or an allied health field. It may also be useful to students with a B.S. degree in biological sciences who wish to prepare for eventual entry in to a doctoral program at Rensselaer or elsewhere. It is possible to enter the doctoral program in biology with a concentration in bioinformatics.

Center for Terahertz Research

Director: Xi-Cheng Zhang

Center Home Page: www.rpi.edu/terahertz

The faculty members of the Center for Terahertz Research are among the world’s first scientists to exploit the unique advantages of terahertz (THz) radiation. Using the relatively unexplored terahertz portion of the electromagnetic spectrum, they are creating innovative imaging and sensing technologies that hold enormous potential in biomedical imaging, genetics diagnostics, microelectronics and the chemical and biological materials identification fields that support homeland defense initiatives.

The promise of terahertz wave radiation, known as “T-rays,” is being realized through ongoing research at the THz Center’s state-of-the-art laboratories: Dr. Xi-Cheng Zhang’s THz Optics lab, Dr. Michael Shur’s THz Electronics lab, Dr. Roland Kersting’s THz Quantum Optics lab, and Dr. Ingrid Wilke’s THz lab. Together, these researchers are overcoming significant challenges posed by the fundamental physics that underlie this large and historically inaccessible portion of the electromagnetic spectrum.

Rensselaer’s THz research team has become the established leader in the development and application of terahertz technology. Their breakthroughs in microscopy, imaging, and development of electro-optic THz emitters and detectors have opened the door to tremendous opportunities for THz radiation throughout major industries.

Research at the center is currently focused on the generation and detection of free-space THz beams using ultra-fast optics and electro-optic crystals. A primary goal is to develop and refine the instrumentation finding higher dynamic ranges, achieving faster data acquisition, and increasing sensitivities to enable the detection of monomolecular layers that will move THz technology beyond its current niche applications to support wider use in biomedicine. During the last several years, scientists and engineers from more than

3 Required if lacking computer science skills.
75 universities, companies, and clinics have visited the labs, and Rensselaer’s THz team has helped scientists from 18 countries learn how to use THz sensors.

Rensselaer’s terahertz research group has received more than $9 million in grants from the National Science Foundation, Army Research Office, Army Research Laboratory, Air Force Office of Scientific Research, Department of Energy, Defense Advanced Research Projects Agency, W.M. Keck Foundation, Research Corporation, IMRA America Incorporated, Molecular OptoElectronic Corporation, 3-D Digital Corp., and Zomega Technology Corporation.

The center’s labs are equipped with the most advanced photonic and opto-electronic instrumentation for generating, measuring and recording picosecond and femtosecond terahertz radiation waves. Rensselaer’s Center for Terahertz Research stands at the forefront of terahertz technology, a science still in its infancy yet expected to become one of the most promising research areas for transformational imaging in the 21st century.

Affiliated Faculty

Roland Kersting, Assistant Professor of Physics

Michael Shur, Patricia W. and C. Sheldon Roberts Professor, Professor of ECSE & Physics, Director, Center for Broadband Data Transport Science and Technology

Ingrid Wilke, Assistant Professor of Physics

Environmental Science

Director: Teofilo Abrajano, Jr.

Program Home Page: http://www.rpi.edu/dept/envsci

Environmental issues continue to be prominent in the lives of everyone. Essentially no place on the planet has escaped perturbation resulting from activities of an ever-growing human population. The challenge is to maintain those attributes of the Earth that make it habitable while at the same time providing for human needs. Science will play an absolutely critical role in enabling technological civilizations to move toward sustainable interactions with the natural world.

While effective environmental scientists must be rigorously educated in one area of science, they must have a perspective far broader than any single science discipline affords. In fact, cognizance of considerations beyond just the sciences is also required. Rensselaer’s environmental science degree addresses these challenges with a multifaceted program.

The Environmental Seminar considers topical environmental issues from numerous perspectives. Through it, students receive a broad overview of environmental challenges in preparation both for their major and for leadership roles in environmental science.

A guided selection of courses in the Humanities and Social Sciences broadens perspective and understanding of the human approach to and interactions with the natural world. Two courses, IENV-4500 and IENV-4700, taken in the final two years of study, enable the student to grasp the broadly varied, interdisciplinary dimensions of the natural environment and its human dimension. The requirement for an intensive environmental experience is an overt acknowledgement that environmental science is a discipline concerned with the natural world.

The science core of 38 credit hours gives each student a common core of 10 courses that introduces important approaches for understanding the natural world. The student-elected concentration in one of the traditional scientific disciplines gives depth in one area of science. With judicious use of the 28 credit hours
of electives, a student can prepare to pursue a number of career options including graduate study in the concentration discipline.

**Research Innovations and Initiatives**
The School of Science offers numerous opportunities for advanced study. Some examples include the impact of acid rain on the Adirondacks, characterization of subsurface microorganisms with the potential for bioremediation, PCB and other contaminant analysis in the Hudson River, studies of aquatic biota in Lake George, and nitrogen cycling in local ecosystems. Students are encouraged to seek research opportunities in environmental science as described in each of the traditional scientific disciplines.

**Faculty Committee**

**Undergraduate Program**

**Environmental Science Curriculum**
This curriculum leads to a B.S. in environmental science. A typical four-year program is illustrated below. However, the order in which students take courses within the first two years is flexible.

### First Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010</td>
<td></td>
<td>MATH-1020</td>
<td></td>
</tr>
<tr>
<td>BIOL-1010</td>
<td></td>
<td>CHEM-1200</td>
<td></td>
</tr>
<tr>
<td>CHEM-1100</td>
<td></td>
<td>ERTH-1200</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2250</td>
<td></td>
<td>BIOL-2120</td>
<td></td>
</tr>
<tr>
<td>ERTH-2210</td>
<td></td>
<td>Concentration and Elective</td>
<td></td>
</tr>
<tr>
<td>PHYS-1100</td>
<td></td>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
</tr>
<tr>
<td>IENV-1920</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Third Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IENV-4500</td>
<td></td>
<td>ERTH-4180</td>
<td></td>
</tr>
<tr>
<td>Concentration and Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Fourth Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>IENV-4700</td>
<td></td>
<td>Concentration and Elective</td>
<td></td>
</tr>
</tbody>
</table>

---

4 Human and Social Science courses should be selected in consultation with the adviser and the Environmental Science Faculty Committee. Examples of environmentally relevant options include: ECON-4230, ECON-4250, IHE-2100, PHIL-4300, STSS-1110, STSS-2300, STSS-4540 and STSS-4320.

5 With permission of the director of Environmental Sciences, a student may elect another Math course (Course numbers MATH-xxxx, MATP-xxxx, or courses cross-listed with these numbers).

6 Each student is required to elect one of the concentrations listed below.

7 Each student is required to engage in an activity that qualifies as an intensive environmental experience as described below.

8 This course is offered every other year in the fall term of odd-numbered years and therefore is a junior year course for some students.
Concentrations
The environmental science degree program requires one concentration. Concentration options and the associated courses are shown below.

**Biology**
(all of the following)
- BIOL-2310 Microbiology
- BIOL-2500 Genetics and Evolution
- BIOL-4620 Molecular Biology
- BIOL-4760 Molecular Biochemistry I
- CHEM-2260 Organic Chemistry II

*(Six of the following courses, four of which must be at the 4000 level)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2100</td>
<td>Introduction to Geophysics</td>
</tr>
<tr>
<td>ERTH-2140</td>
<td>Introduction to Geochemistry</td>
</tr>
<tr>
<td>ERTH-2330</td>
<td>Earth Materials</td>
</tr>
<tr>
<td>ERTH-2610</td>
<td>Oceanography</td>
</tr>
</tbody>
</table>

**Chemistry**
(all of the following)
- CHEM-2030 Inorganic Chemistry I
- CHEM-2150 Equilibrium Chemistry and Quantitative Analysis
- CHEM-4450 Macroscopic Physical Chemistry
- CHEM-4810 Chemistry of the Environment

*(one of the following)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOL-2310</td>
<td>Freshwater Ecology Laboratory</td>
</tr>
<tr>
<td>BIOL-4850</td>
<td>Principles of Ecology</td>
</tr>
</tbody>
</table>

*(one of the following)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2260</td>
<td>Organic Chemistry II</td>
</tr>
<tr>
<td>CHEM-4460</td>
<td>Microscopic Physical Chemistry</td>
</tr>
</tbody>
</table>

*(one of the following)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM-2950</td>
<td>Undergraduate Research (3 credits)</td>
</tr>
<tr>
<td>CHEM-4xxx</td>
<td>Chemistry Elective</td>
</tr>
<tr>
<td>CHEM-4990</td>
<td>Senior Thesis</td>
</tr>
</tbody>
</table>

**Computer Science—students may choose from two options:**

**Option A (Computer Science)**
(all of the following)
- CSCI-1100 Computer Science I
- CSCI-1200 Computer Science II
- CSCI-2300 Data Structures and Algorithms
- CSCI-2400 Models of Computation
- CSCI-2500 Computer Organization
- One course from the series CSCI-4xxx

*(all of the following)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II</td>
</tr>
<tr>
<td>CSCI-2300</td>
<td>Data Structures and Algorithms</td>
</tr>
<tr>
<td>CSCI-2400</td>
<td>Models of Computation</td>
</tr>
<tr>
<td>CSCI-2500</td>
<td>Computer Organization</td>
</tr>
<tr>
<td>CSCI-4xxx</td>
<td>Chemistry Elective</td>
</tr>
</tbody>
</table>

**Option B (Scientific Computation)**
(all of the following)
- MATH-2010 Multivariable Calculus and Matrix Algebra
- MATH-2400 Introduction to Differential Equations
- CSCI-1100 Computer Science I
- CSCI-1200 Computer Science II
- CSCI-2300 Data Structures and Algorithms
- CSCI-4800 Numerical Computing
- CSCI-4800 Numerical Computing

*(one of the following)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-2400</td>
<td>Introduction to Differential Equations</td>
</tr>
<tr>
<td>CSCI-1100</td>
<td>Computer Science I</td>
</tr>
<tr>
<td>CSCI-1200</td>
<td>Computer Science II</td>
</tr>
<tr>
<td>CSCI-2300</td>
<td>Data Structures and Algorithms</td>
</tr>
<tr>
<td>CSCI-4800</td>
<td>Numerical Computing</td>
</tr>
</tbody>
</table>

**Geology**
*(Six of the following courses, four of which must be at the 4000 level)*

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERTH-2100</td>
<td>Introduction to Geophysics</td>
</tr>
<tr>
<td>ERTH-2140</td>
<td>Introduction to Geochemistry</td>
</tr>
<tr>
<td>ERTH-2330</td>
<td>Earth Materials</td>
</tr>
<tr>
<td>ERTH-2610</td>
<td>Oceanography</td>
</tr>
<tr>
<td>ERTH-2120</td>
<td>Structural Geology</td>
</tr>
<tr>
<td>ERTH-4710</td>
<td>Groundwater Hydrology</td>
</tr>
<tr>
<td>ERTH-4540</td>
<td>Organic Geochemistry</td>
</tr>
<tr>
<td>ERTH-4070</td>
<td>Sedimentology</td>
</tr>
<tr>
<td>ERTH-4190</td>
<td>Environmental Measurements</td>
</tr>
<tr>
<td>ERTH-4690</td>
<td>Aqueous Geochemistry</td>
</tr>
</tbody>
</table>
Mathematics

(both of the following)

MATH-2010 Multivariable Calculus and Matrix Algebra
MATH-2400 Introduction to Differential Equations

(one of the following)

MATH-4200 Mathematical Analysis I
MATH-4600 Advanced Calculus

(two of the following)

MATH-4210 Mathematical Analysis II
MATH-4300 Introduction to Complex Variables: Theory and Applications
MATH-4400 Introduction to Dynamical Systems and Chaos
MATH-4500 Methods of Partial Differential Equations of Mathematical Physics
MATH-4800 Numerical Computing
MATH-4820 Introduction to Numerical Computing for Differential Equations
MATP-4600 Probability Theory and Applications
MATP-4620 Mathematical Statistics

Physics

(all of the following)

MATH-2400 Introduction to Differential Equations
PHYS-1200 Physics II
PHYS-2100 Introduction to Theoretical Physics

(both of the following)

MATH-2400 Introduction to Differential Equations
PHYS-1200 Physics II
PHYS-2100 Introduction to Theoretical Physics

Minor Programs

Sustainable stewardship of the environment is the single most important challenge facing the world, and this minor is ideal for students wishing to develop a multidisciplinary background in environmental science. The program of study requires a minimum of four courses of which three are required. These required courses include: BIOL-4850, CHEM-4810, and ERTH-4180. A minimum of one additional course must be selected from the list below. At the discretion of the adviser and the environmental science program director, the student may take an alternative not on the list, or complete a four-credit research project. At least three of the four courses required for the minor must be at the 4000 level.

ENVE-4310 Applied Hydrology and Hydraulics
MANE-4700 Solar Devices and Renewable Energy
BIOL-4310 Industrial Microbiology
BIOL-4320 Geomicrobiology
BIOL-4440 Microbial Ecology
ERTH-4690 Aqueous Geochemistry

BIOL-4700 Fresh Water Ecology Laboratory
BIOL-4870 Environmental Toxicology
ERTH-4710 Groundwater Hydrology
ERTH-4690 Aqueous Geochemistry
ERTH-4180 Environmental Geology
ERTH-4540 Organic Geochemistry

ERTH-4500 Global Environmental change

Students interested in developing a broad, multidisciplinary background in energy to complement their more focused major program may also consider another minor option—the Interschool Minor in Energy. See Interdisciplinary Programs and Research in the Humanities and Social Sciences section of this catalog for details on this program.

Special Opportunities in Environmental Science

Environmental Studies Program

Building on the unusual strength and breadth of Rensselaer’s synthesis of engineering, science, and the humanities and social sciences, the Environmental Studies Program offers students a unique educational opportunity to develop a truly multidisciplinary approach to environmental studies.

Students who enter Rensselaer in the Environmental Studies Program will take a broad range of basic courses in their first two years. They then choose one of five majors: economics (with an ecological eco-
nomics focus), environmental engineering, environmental science (with a concentration in a specific area of science), hydrogeology, or science, technology, and society (with an environmental focus). Students may also choose the dual major Ecological Economics, Values, and Policy program including economics and science, technology, and society. To complement their major programs, students may earn a wide variety of minors. All the majors in the program offer their own environmental minors, and the Schools of Architecture and Management offer special environmental courses as well. Rather than becoming narrow specialists, students participating in the Environmental Studies Program will receive a multidisciplinary education that prepares them to address a variety of environmental problems.

See Interdisciplinary Programs and Research in the Humanities and Social Sciences section of this catalog for a complete description of this program.

**Intensive Environmental Experience**

In consultation with their adviser and with the approval of the director of the Environmental Science Program, students may select and engage in an intensive activity related to the environment. They may do so either directly (as in “natural world” experience) or indirectly through temporary employment (e.g., as a co-op or intern) or through participation in an environmental research monitoring or assessment program. The environmental experience, envisioned typically as a summer activity occurring after the sophomore or junior year, must last at least a month and, in some cases, may be associated with earning academic credit. To successfully fulfill this requirement, students must document the experience and obtain approval for it from the Environmental Science Faculty Committee.

**Interdisciplinary Science**

**Chair:** Samuel C. Wait, Jr.

The Interdisciplinary Science curriculum provides an education in the sciences for undergraduate students whose interests range outside the traditional disciplines and career paths. It is suitable for students wishing to combine sciences in innovative ways or to combine science with more humanistic studies such as management, law, education, communication, public service, economics, policy-making, or community affairs. Students who are undecided among the sciences, have particular special interests, or seek non-traditional career paths may follow the Interdisciplinary Science curriculum while becoming familiar with their options.

The introductory courses recommended are the same as those for departmental science majors. However, the deep undergraduate concentration in a single science area that is characteristic of departmental majors is replaced by a broader coverage of science areas and a greater choice of courses, including nonscience courses. Students vary their programs to emphasize preparation for their own particular professional objectives.

This curriculum is suited especially for students who wish to:

- prepare for work in interdisciplinary areas of science such as material science or climatology
- combine a strong foundation in science with studies in arts, philosophy, psychology, management, economics, or public affairs
- develop a broader and more interdisciplinary education in the health-related science areas
- prepare to teach science at the secondary school or junior college level
- do graduate work in the history or philosophy of science or are interested in science as part of American culture.

A bachelor’s program in interdisciplinary science is excellent preparation for an MBA or a degree in a field such as law or communications. Combinations such as these prepare students for many effective roles in today’s community.
Undergraduate Program

The core course requirements of the Interdisciplinary Science curriculum are 16 courses, each carrying four or more credits, chosen from offerings in the fields of biology, biochemistry/biophysics, chemistry, computer science, environmental sciences, geology, mathematical sciences (course codes MATH and MATP) and physics. Each curriculum must include courses in at least four science disciplines. For this purpose, course codes MATH and MATP are a single discipline. In order to ensure depth and breadth, the curriculum must consist of at least eight courses in one discipline and four courses in a second discipline. The remaining four courses are to be chosen from at least two other disciplines. The eight-course concentration must include two or more three or four credit courses at the 4000 level. Other Institute-wide requirements for graduation such as the humanities and social sciences core requirements must also be met.

The student’s specific objectives will determine the balance of the curriculum to yield a total of 124 credits needed for graduation.

This curriculum leads to the Bachelor of Science in Interdisciplinary Science. The program can be coupled with other programs, on or off the Rensselaer campus, to form a combined five-year program leading to a B.S. in Interdisciplinary Science together with a master’s degree in a professional area, such as business administration or psychology. Effective courses can be chosen from any of Rensselaer’s five schools or departments and from nearby institutions in the Hudson-Mohawk consortium of colleges.

A typical Interdisciplinary Science degree program is shown below.

<table>
<thead>
<tr>
<th>First Year</th>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-1010</td>
<td>Calculus I .........................................4</td>
<td>MATH-1020</td>
<td>Calculus II ........................................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>...............4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td></td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Elective</td>
<td>.............4</td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>.............4</td>
<td>Elective</td>
<td>.............4</td>
<td></td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td></td>
</tr>
</tbody>
</table>

Second Year

<table>
<thead>
<tr>
<th>Fall</th>
<th>Credit hours</th>
<th>Spring</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
</tr>
<tr>
<td>Science Option 9,10</td>
<td>.............................4</td>
<td>Science Option 9,10</td>
<td>.............................4</td>
</tr>
<tr>
<td>Elective</td>
<td>.............4</td>
<td>Elective</td>
<td>.............4</td>
</tr>
<tr>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
<td>Hum. or Soc. Sci. Elective</td>
<td>.............4</td>
</tr>
</tbody>
</table>

9 Science options are chosen from among the offerings of biology, chemistry, computer science, geology, mathematics or physics. Appropriate courses for the first year are:

- BIOL-1010 Introduction to Biology
- CSCI-1100 Computer Science I
- BIOL-1020 Introduction to Biology Lab.
- CSCI-1200 Computer Science II
- BIOL-2120 Intro. to Cell and Molecular Biology
- EARTH-1100 Geology I
- CHEM-1100 Chemistry I
- ERTH-1200 Geology II
- CHEM-1200 Chemistry II
- PHYS-1100 Physics I
- PHYS-1200 Physics II

10 Science options should be planned with an adviser and can occur at any time in the curriculum. All four options must be fulfilled in order to receive an Interdisciplinary Science degree.

Option I is a series of eight (8) courses of four credits each chosen from a single science or mathematics discipline. At least two of these courses must be at the 4000 level.

Option II is a series of four courses in a single science or mathematics discipline that is different from the discipline in Option I.

Option III is a course in a single discipline that is different from that in Option I or II.

Option IV is a course in a single discipline that is different from that in Option I, II, or III.

11The total number of credits required for graduation in the School of Science is 124; electives are generally offered as four credits. If three credit courses are taken or transferred, the total must still be 124 credits for graduation.
Traditionally, graduate degrees have focused on a single subject matter such as chemistry, physics, or mathematics. However, current and expected future trends in the working environment show that jobs will increasingly bridge more than one area of specialization. Biochemistry, for example, which is of major importance in today’s society, now spans two or three disciplines. Practitioners must have a thorough knowledge of several areas of chemistry and biology. The same is true of bioinformatics, a new multidisciplinary field that depends on expertise in biology and computational sciences. These are just two in a growing number of fields that cross specializations. Rensselaer’s M.S. and Ph.D. in Multidisciplinary Science meet the need of graduates who anticipate careers in such occupations.

Rensselaer strongly emphasizes interdisciplinary research programs that bridge disciplines within the School of Science and between the School of Science and the School of Engineering. The George M. Low Center for Industrial Innovation was specifically constructed to house research centers such as the Center for Integrated Electronics, the Center for Composite Materials and Structures, the Center for Automation Technologies, the Center for Multiphase Research, and the Scientific Computation Research Center.

### Multidisciplinary Science

Traditionally, graduate degrees have focused on a single subject matter such as chemistry, physics, or mathematics. However, current and expected future trends in the working environment show that jobs will increasingly bridge more than one area of specialization. Biochemistry, for example, which is of major importance in today’s society, now spans two or three disciplines. Practitioners must have a thorough knowledge of several areas of chemistry and biology. The same is true of bioinformatics, a new multidisciplinary field that depends on expertise in biology and computational sciences. These are just two in a growing number of fields that cross specializations. Rensselaer’s M.S. and Ph.D. in Multidisciplinary Science meet the need of graduates who anticipate careers in such occupations.

Rensselaer strongly emphasizes interdisciplinary research programs that bridge disciplines within the School of Science and between the School of Science and the School of Engineering. The George M. Low Center for Industrial Innovation was specifically constructed to house research centers such as the Center for Integrated Electronics, the Center for Composite Materials and Structures, the Center for Automation Technologies, the Center for Multiphase Research, and the Scientific Computation Research Center.

### Requirements

#### Third Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Option 902</td>
<td>Science Option 930</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Fourth Year

<table>
<thead>
<tr>
<th>Fall Credit hours</th>
<th>Spring Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Option 902</td>
<td>Science Option 930</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

5 Science options are chosen from among the offerings of biology, chemistry, computer science, geology, mathematics or physics. Appropriate courses for the first year are:

- **BIOL-1010** Introduction to Biology
- **CHEM-1100** Chemistry I
- **CSCI-1100** Computer Science I
- **ERTH-1200** Geology II
- **BIOL-1020** Introduction to Biology Lab.
- **CHEM-1200** Chemistry II
- **CSCI-1200** Computer Science II
- **PHYS-1100** Physics I
- **BIOL-2120** Intro. to Cell and Molecular Biology
- **PHYS-1200** Physics II
- **EARTH-1100** Geology I

6 Science options should be planned with an adviser and can occur at any time in the curriculum. All four options must be fulfilled in order to receive an Interdisciplinary Science degree.

- **Option I** is a series of eight (8) courses of four credits each chosen from a single science or mathematics discipline. At least two of these courses must be at the 4000 level.
- **Option II** is a series of four courses in a single science or mathematics discipline that is different from the discipline in Option I.
- **Option III** is a course in a single discipline that is different from that in Option I or II.
- **Option IV** is a course in a single discipline that is different from that in Option I, II, or III.
Students within multidisciplinary graduate programs are under the tutelage of faculty from more than one discipline. This highly knowledgeable faculty will determine which courses the student needs, develop appropriate examinations, and supervise research activities. The dean of science appoints the doctoral committee and supervises the student’s overall progress.

Students interested in pursuing such multidisciplinary graduate programs must follow Rensselaer’s standard graduate admission guidelines and must seek approval from faculty representing all disciplines related to their individual programs.

The Darrin Fresh Water Institute

Director: Sandra A. Nierzwicki-Bauer

Associate Directors: Richard F. Bopp, Charles W. Boylen

The Margaret A. and David M. Darrin ’40 Fresh Water Institute, with research facilities both on the main campus and at the field station on Lake George, provides opportunities for Rensselaer undergraduate and graduate students, faculty, and visiting scientists to study a number of ecosystems and conduct basic and applied research on environmental problems. The field station, located at Bolton Landing, N.Y., includes an Adirondack lodge (which houses a multi-computing facility), several small cottages, a boathouse, and a 7,500-square-foot teaching and research facility.

Computer-simulation models integrate field studies with laboratory experiments. Studies of ecosystem function and the influence of human activities on specific environmental systems help prevent or minimize adverse environmental impacts. The Lake George ecosystem has been under intensive study for the past 30 years and will continue to be one focal point for the Institute’s research activities. Other areas of research concentration include the Hudson River ecosystem, the effects of acid rain on the Adirondacks, the effects of land use on watersheds, studies and controls of exotic species (e.g. Eurasian Milfoil and Zebra Mussels), and the effects of environmental pollutants on both terrestrial and aquatic systems.

The Institute fosters a multidisciplinary team approach in both education and research with participants from the various disciplines within the School of Science, as well as other environmental programs across the Rensselaer campus. Other university laboratories and field stations also join in cooperative studies.

The Darrin Fresh Water Institute also has facilities on campus with the W.M. Keck Foundation Water Quality Laboratory. This laboratory is equipped with state-of-the-art instrumentation to conduct sophisticated studies of water quality and the fate of pollutants. Analytical equipment to examine the chemistry and microscopy equipment to study interactions between organisms and substrates are components of this interdisciplinary research laboratory, which is located in the Materials Research Center.

Additionally, on-campus facilities include the iEAR/Darrin Fresh Water Institute Environmental Multimedia Studio. Environment-related multimedia resources are produced in this studio. Such projects include the production and cablecasting of the Darrin Fresh Water Institute summer lecture series and the production of the DFWI home page, which includes a “virtual tour” of research facilities at the Bolton Landing field station. Visit the site at http://www.rpi.edu/dept/bio/fwi/.

The Darrin Fresh Water Institute is an integral part of Rensselaer’s environmental initiative. Summer courses involving both classroom instruction and intensive field studies are held at the Lake George site. Student participation in research activities at the Institute is encouraged with a number of student internships available each summer.
New York Center for Studies on the Origins of Life

**Director:** James P. Ferris, Department of Chemistry

**Associate Directors:** Douglas C.B. Whittet, Department of Physics, Applied Physics, and Astronomy, and John W. Delano, Department of Earth and Atmospheric Sciences, the State University of New York at Albany

**Assistant Director:** Ann Marie Strack

**Program Home Page:** [http://www.origins.rpi.edu](http://www.origins.rpi.edu)

The New York Center for Studies on the Origins of Life involves faculty, postdoctorals, graduate students, and undergraduate students from Rensselaer Polytechnic Institute, the State University of New York at Albany, and the College of Saint Rose in education and research programs seeking to understand how life originated and evolved. Some of the major research areas are listed below.

**Research Innovations and Initiatives**

**Sources of Organics on the Primitive Earth**

Two major hypotheses for the origins of organics on the early Earth are being evaluated in the proposed research. First is the idea that the organic precursors to life were initially formed in the interstellar medium and, after processing during the formation of the solar system, were delivered to the Earth's surface. The second hypothesis is that a reducing atmosphere formed by volcanic outgassing from a reduced mantle on the primitive Earth was the source of the organic precursors for life.

**Interstellar Sources**

The organics present in the interstellar medium are investigated by ground-based and orbiting observatories in the two–25 microns wavelength range of the infrared by Douglas C.B. Whittet. These measurements have been made on the Infrared Space Observatory and on ground-based observatories in Hawaii and Chile. The high resolving power of these telescopes allows the detection of infrared frequencies characteristic of functional groups in organic molecules.

**Shock Processing of Prebiotic Materials**

Organic molecules formed in the interstellar medium are brought to the solar nebula in the icy coatings on dust grains. Wayne Roberge is simulating the processing of ices by the accretion shock where infalling dust enters the solar nebula, by shocks inside the solar nebula, and by external wind shocks where the bipolar outflow strikes infalling material. We find that nebular and accretion shocks can anneal the ices, greatly altering the ices’ capacity to retain volatile organics. The efficiency of annealing depends strongly on heliocentric distance, with important consequences for the relative volatile content of Jupiter family versus Kuiper Belt comets.

**Reactions During Planet Formation**

An important stage of organics processing is in the planetesimals created in the early stages of the planets, moons, asteroids, and comets. When radioactive decay heated these bodies, the frozen water in them liquefied. The reaction with water and the radiation from radioactive elements further altered the organics. Meteorites are fragments from asteroids which, together with comets, are believed to have brought these organics with them when they impacted the primitive Earth. These organics are believed to be the major source of starting materials for the origins of life. Michael J. Gaffey is using infrared spectroscopic measurements to investigate the structures of the organics on the outer belt asteroids.
The Oxidation State of the Earth’s Crust and Mantle
John W. Delano has determined the original oxidation state of ancient volcanic rocks up to 3.96 billion years ago using the geochemistries of Cr and V. The results of that investigation were published in late 2001 and indicate that high-temperature volcanic gases were not a likely source of chemically reduced gases at any time during the last 3.96 billion years. Work is proceeding in an effort to determine the Earth’s oxidation state of high-temperature volcanic gases prior to 3.96 billion years ago to see if they might have served as a source of gas species useful for the formation of prebiotic molecules.

Atmospheres of Titan and Jupiter
James P. Ferris is investigating through laboratory experiments the photochemical processes in the atmospheres of Titan and Jupiter. Using a flow chemical reactor where it is possible to irradiate the low-mixing ratios of atmospheric organics, the photochemical transformations in proposed primitive atmospheres are being investigated. With a flow reactor, it is possible to obtain sufficient amounts of reactants for their identification and quantification by nuclear magnetic resonance (NMR) and mass spectrometry.

The RNA World
Ribonucleic acid (RNA) was the most important biopolymer for the first life on Earth. The emphasis in this research is the prebiotic synthesis of RNA and the search for evidence of the RNA world in the introns of primitive life on Earth today.

Thioacids as Phosphorylating Reagents
William J. Hagan is investigating the thermal and photochemical formation of thioacids, which represent precursors of high-energy phosphate donors that might have promoted the phosphorylation of sugars, such as ribose. The latter is a possible step in the conversion of nucleosides to nucleotides, the building blocks of RNA.

Prebiotic RNA Synthesis
James P. Ferris is investigating the mineral-catalyzed formation of RNA from activated mononucleotides. The research will center on the origin of the RNA world, where RNA or RNA-like molecules have been proposed to be the most important biopolymers in the first life on Earth.

Search for Catalytic RNA Sequences
The third research emphasis is Sandra A. Nierzwicki-Bauer’s search for evidence of the postulated RNA world in the extant life on the Earth today. If RNA was the basis for the first life on Earth, vestiges of the sequences of ancient catalytic RNA in the RNA sequences of slow-growing, deep subsurface microorganisms may be found. The presence of the nucleotide sequence of the Group I intron, which catalyzes the splicing of RNA, is the object of the search in the introns of the subsurface bacteria.

The Impact History of the Primitive Earth
John W. Delano is determining the timing of large impact events on the Moon, and by analogy on the Earth, and the implications for the sustainability of life on the early Earth. Impact-produced glasses from three Apollo landing sites are being chemically and isotopically analyzed individually to determine the ages of impact events on the Moon. This dating makes it possible to determine whether the impact flux was simple (e.g., monotonic decrease through time) or complex (e.g., late cataclysm).
Minor Programs

The Biology, Biochemistry and Biophysics, Chemistry, Earth and Environmental Sciences, and Physics Departments participate in a multidisciplinary minor in Astrobiology for students majoring in these or other disciplines. Students must take a minimum of 16 credits of course work in this field. These courses include ASTR-4510, and ISCI-4500, four credits each, and two semesters of the one-credit course ISCI-4510. A further two courses outside the major field of study are also required, selected from the following:

<table>
<thead>
<tr>
<th></th>
<th>Course Name</th>
<th>Credits</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENVE-2110</td>
<td>Introduction to Environmental Engineering</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>BCBP-4860</td>
<td>Protein and Nucleic Acid Structure</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CHEM-2250</td>
<td>Organic Chemistry I</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BIOL-4320</td>
<td>Geomicrobiology</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>CHEM-4810</td>
<td>Chemistry of the Environment</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>BIOL-4440</td>
<td>Microbial Ecology</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>ASTR-4510</td>
<td>Introduction to Astronomy and Astrophysics</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

For a double major, the requirement that the two selected courses must be outside the major field of study is reduced to one provided both majors are in the primary relevant areas of study (i.e. biology, chemistry, geology, and physics).

Affiliated Faculty

Earth and Environmental Sciences: J. Abrajano, M.J. Gaffey

Natural Sciences, the College of Saint Rose: W.J. Hagan

Biology: S.A. Nierzwicki-Bauer

Physics, Applied Physics, and Astronomy: W. Roberge

New York State Center for Polymer Synthesis

Director: Brian Benicewicz, Department of Chemistry

Center Home Page: http://www.rpi.edu/polymers

Dedicated in 1998, the New York State Center for Polymer Synthesis provides bridges for companies to work with Rensselaer faculty and students in designing, producing, and testing novel polymers than can change the way people live and work. Many high-technology industries remain materials limited, meaning that significant improvements in technology could be made if new, structurally tailored polymers with specific, predictable properties were prepared. Often, the creation of new polymers spawns entirely new industries. Thus, the center is committed to working with companies on their polymer-related problems. An extensive foundation in polymer science and special expertise in polymer synthesis has made the center highly successful in these endeavors.

To facilitate its research projects, the center houses advanced technology for the discovery, scale-up, processing, and evaluation of unique polymers. The Center’s focus is threefold: groundbreaking research, corporate and government partnerships, and undergraduate and graduate research.

Current research under way at the center includes work on protein design and synthesis, studies of protein folding and its effect on diseases, using enzymes for polymer synthesis, block copolymers, inorganic polymers, controlled free radical polymerizations, preparing polymer membranes for fuel cells, and creating polymer nanocomposites. Award-winning research that involves turning waste cellulose from paper mills into the raw materials that go into new plastics has also been conducted at the center. In addition, it is also the site of world-renowned and pioneering work on photo-initiated polymerizations and their applications in photoresists and adhesive curing.
Affiliated Faculty

Chemical Engineering: G. Belfort, S. Cramer, J. Dordick, S. Garde, R. Kane, S. Kumar, B. Nauman


Materials Science and Engineering: P.M. Ajayan, C. Chung, R. Ozisik, L. Schadler, S. Sternstein
# Table of Contents

- Air and Space Studies 407
- Military Science 408
- Naval Science 409
Reserve Officers Training Corps

The Reserve Officers Training Corps (ROTC) programs are elective programs for students who desire commissions in the armed forces. The objective is to develop professional officers who have varied educational backgrounds in major fields of interest and have the professional knowledge and standards needed for future growth. Although the aim in each service is the same, the individual programs differ because of varying responsibilities assigned newly commissioned officers in the three services and differing plans of continuing education.

Program benefits are available only to students who meet the requirements and standards of the particular branch of the armed forces sponsoring the ROTC unit. Each armed services/ROTC program has its own requirements and standards.

Students who satisfy the requirements for baccalaureate degrees become eligible for commissions on completion of the appropriate ROTC programs. ROTC programs are undertaken concurrently with baccalaureate degree studies, with the following provisions:

■ Certain courses approved by the appropriate ROTC department chairman may be substituted for ROTC courses to fulfill ROTC program requirements.

■ An ROTC educational program must incorporate the course work that leads to a commission. In addition, any student may take ROTC courses as free electives. Although there is no fixed limit to the number of ROTC courses that can count toward a baccalaureate degree, at least six credit hours of courses in ROTC may be counted as general elective credits in the appropriate baccalaureate program. Only the student’s curriculum and faculty adviser limits the number of ROTC credit hours applied to a degree. However, an ROTC course should not replace a humanities and social sciences core course (unless the School of Humanities and Social Sciences accepts a specific course for this purpose). Also an ROTC course should not replace a technical elective (unless a specific course is accepted for this purpose by the student’s department chairperson).

■ Cross-Registration: The home institution may limit the number of credit hours and/or grades to be applied. Refer to home institution catalog.

Air and Space Studies

Chairman Col. Thomas D. Bell

The Department of Air and Space Studies offers an elective program to eligible male and female students who are U.S. citizens wishing to pursue commissioning as future Air Force officers. The program has two phases, a General Military Course and a Professional Officer Course. The General Military Course may be taken during the first two years or during a special five-week summer course. After the General Military Course, students compete for entry into the two-year Professional Officer Course.

Admission to the Professional Officer Course is based on demonstrated proficiency in the General Military Course, medical qualifications, academic standing, physical conditioning requirements, the successful completion of field training, aptitude for further officer training, and citizenship.

Air Force scholarships are awarded on a merit basis to high school seniors and full-time college students who meet specific program requirements. Multiple-year scholarships are available, as well as some specialized one-year programs and incentives. Refer to the Undergraduate Financial Aid section, ROTC Financial Aid Programs. For more information, you may also visit our Web site at the following address: http://www.rpi.edu/dept/afrotc or call (518) 276-6236.
**Faculty**

**Professor:** T. D. Bell  
**Assistant Professors:** A.E. DeRosa, J.L. Gilpin, K.L. Strait

---

**Air Force Reserve Officers Training Corps**

### General Military Course

#### First Year

**Credit hours**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAF-1010</td>
<td>Air and Space Studies 100A</td>
<td>1</td>
</tr>
<tr>
<td>USAF-0010</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USAF-1020</td>
<td>Air and Space Studies 100B</td>
<td>1</td>
</tr>
<tr>
<td>USAF-0020</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Second Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAF-2030</td>
<td>Air and Space Studies 200A</td>
<td>1</td>
</tr>
<tr>
<td>USAF-0030</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USAF-2040</td>
<td>Air and Space Studies 200B</td>
<td>1</td>
</tr>
<tr>
<td>USAF-0040</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

### Professional Officer Course

#### Third Year

**Credit hours**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAF-2050</td>
<td>Air and Space Studies 300A</td>
<td>3</td>
</tr>
<tr>
<td>USAF-0050</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USAF-2060</td>
<td>Air and Space Studies 300B</td>
<td>3</td>
</tr>
<tr>
<td>USAF-0060</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

#### Fourth Year

**Credit hours**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Description</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAF-2070</td>
<td>Air and Space Studies 400A</td>
<td>3</td>
</tr>
<tr>
<td>USAF-0070</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USAF-2080</td>
<td>Air and Space Studies 400B</td>
<td>3</td>
</tr>
<tr>
<td>USAF-0080</td>
<td>Air Force Leadership Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

### Supplemental Courses

In order to receive a commission, individuals must also meet weight, fitness, academic, and military retention standards.

Air Force uniforms will be issued only to students meeting all Air Force requirements.

---

**Military Science**

**Chairman:** Lt. Col. Thomas G. Donnelly

The Office of Military Science offers an elective program to qualify male and female students for commissions as officers in the U.S. Army. The Army ROTC program has two phases: a basic course, normally taken during the freshman and sophomore years, and an advanced course, normally taken during the junior and senior years.

Army ROTC scholarships are awarded to high school seniors and first- and second-year Army ROTC students.

All Army ROTC instruction is provided on campus. To register, the student should visit the Office of Military Science, Room 407, AS & RC Building. For further information call collect (518) 276-6254.
Faculty*
Adjunct Professors
Eric H. Bennett, Thomas G. Donnelly, William F. Fox

Army Reserve Officers Training Corps Program

Basic Course
First Year
USAR-1010 Fundamentals of Military Science I .................................................................1
USAR-1020 Fundamentals of Military Science II ...............................................................1

Second Year
USAR-2010 History of Military Applications of Technology ...............................................1
USAR-2020 Applied Leadership ........................................................................................1

Leadership Laboratory  Leadership laboratory stresses leadership opportunities, instruction in basic military skills, and physical fitness activities to include the following subjects: rappelling; junior leader skills; marksmanship; weapons familiarization; map reading; tactics; compass; military ceremonies; communications techniques; nuclear, biological, chemical defense and first aid. Leadership laboratories occur monthly and are outside the normal class schedules. Only contracted and scholarship cadets are required to attend.

Military Science

Advanced Course
Third Year
USAR-2060 Applied Military Leadership I ........................................................................2
USAR-2070 Applied Military Leadership II .......................................................................2

Fourth Year
USAR-4010 Military Management Systems I ....................................................................2
USAR-4020 Military Management Systems II ....................................................................2

Supplemental Courses  All students who intend to progress through the advanced course must take a course in American History subject to the approval of the Military Science adviser.

Naval Science

Chairman: Capt. George Kasten, III

The Department of Naval Science offers an elective program to qualify male and female students for commissions as officers in the U.S. Naval Reserve or Marine Corps. There are two categories of students: (1) scholarship and (2) college program.

Scholarship students receive up to four years of full scholarship benefits and a monthly stipend. Awards are based on an annual nationwide competition conducted by the Department of the Navy. College program students receive basic benefits and are given the opportunity to become scholarship students.

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.
# Faculty*

**Professor:** G.D. Kasten  
**Associate Professor:** A.G. Hendrickson  
**Assistant Professors:** G.L. Badget, R.E. Fulkerson, D.A. Zallnick

---

## Naval Reserve Officers Training Corps Program

### Basic Course

<table>
<thead>
<tr>
<th>First Year</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA-1010 The Military and Its Place in Society (^1)</td>
<td>1</td>
</tr>
<tr>
<td>USNA-0010 Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-2020 Seapower and Maritime Affairs</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0020 Drill/Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

Summer Training (scholarship students only)

<table>
<thead>
<tr>
<th>Second Year</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA-2030 Naval Leadership &amp; Management I</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0030 Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-2040 Naval Ships Systems (^1,2)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0040 Drill/Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

Summer Training (scholarship and two-year students)

### Advanced Course

<table>
<thead>
<tr>
<th>Third Year</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA-2050 Navigation (^1)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0050 Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-2060 Naval Operations (Navy only) (^2)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-2150 Evolution of Warfare (^1) (Marines only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0060 Drill/Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

Summer Training (all students)

<table>
<thead>
<tr>
<th>Fourth Year</th>
<th>Credit hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>USNA-2070 Naval Ships Systems II (^1,2)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0070 Drill/Laboratory</td>
<td>0</td>
</tr>
<tr>
<td>USNA-4190 Naval Leadership and Ethics (Navy only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-2170 Amphibious Warfare (^1) (Marines only)</td>
<td>3</td>
</tr>
<tr>
<td>USNA-0080 Drill/Laboratory</td>
<td>0</td>
</tr>
</tbody>
</table>

### Supplemental Courses

In addition, the NROTC midshipman must complete the following courses to ensure minimum acceptable standards for commissioning:

* Departmental faculty listings are accurate as of the date generated for inclusion in this catalog. For the most up-to-date listing of faculty positions, including end-of-year promotions, please refer to the Faculty Roster section of this catalog, which is current as of the May 2003 Board of Trustees meeting.

\(^1\) Not required of two-year students; covered in summer institute.  
\(^2\) Not required of Marine Corps option students.  
\(^3\) Marine Corps option only.
MATH-1010 Calculus
MATH-1020 Calculus
PHYS-1100 Physics
PHYS-1200 Physics
One course in computer science.
One approved course in political science/international affairs.
Two approved courses in English and writing assessment.

Course Descriptions
For course descriptions see the Course Descriptions section of this catalog under the designation USNA.

2 Not required of Marine Corps option students.
Course Descriptions

Descriptions of all undergraduate and graduate courses are given on the pages that follow. The sections are alphabetized according to the four letter department names (see below). The credit hours for each course are stated at the end of the description; contact hours are stated only if they differ from the credit hours.

It is generally expected that, when so indicated, courses will be given in the term shown. However, the university reserves the right to withdraw any course for which interest is insufficient or to make changes in time of offering or in staff. Current course listings are published each term, prior to registration, in posted announcements.

The course numbering system is alphanumeric beginning with a four-letter department name, followed by a dash, the three-digit course number, and a zero.

Four-Letter Subject Codes by School

**Architecture (SOA)**
ARCH Architecture
LGHT Lighting

**Engineering (SOE)**
BMED Biomedical Engineering
CHME Chemical Engineering
CIVL Civil Engineering
DSES Decision Sciences and Engineering Systems
ECSE Electrical, Computer, and Systems Engineering
ENGR General Engineering
EPOW Electrical Power Engineering
ENVE Environmental Engineering
ESCI Engineering Science
MANE Mechanical, Aerospace, and Nuclear Engineering
MTLE Materials Science and Engineering

**Humanities and Social Sciences (Humanities Courses) (HSSH)**
ARTS Arts
COMM Communication
IHSS Interdisciplinary Humanities and Social Sciences
LANG Foreign Languages and Literature
LITR Literature
PHIL Philosophy
STSH Science and Technology Studies (Humanities Courses)
WRIT Writing

**Humanities and Social Sciences (Social Sciences Courses) (HSSS)**
ECON Economics
PSYC Psychology
STSS Science and Technology Studies (Social Sciences Courses)
Information Technology (IT)
ITEC Information Technology

Management and Technology (LSOM)
MGMT Management

Science (SOS)
ASTR Astronomy
BCBP Biochemistry and Biophysics
BIOL Biology
CHEM Chemistry
CISH Computer Science at Hartford
CSCI Computer Science
ISCI Interdisciplinary Science
ERTH Earth and Environmental Science
MATH Mathematics
MATP Mathematical Programming, Probability, and Statistics
PHYS Physics

Interdisciplinary and Other (MISC)
IENV Interdisciplinary Environmental Courses
USAF Aerospace Studies (Air Force ROTC)
USAR Military Science (Army ROTC)
USNA Naval Science (Navy ROTC)
NSST Natural Science for School Teachers
approach have to the formative conditions of the con-

Two very direct questions explored as to its ontological, epistemological, value, and consequences of those choices. Each of the approaches is used as foils in order to better understand one’s own individual approach to design. The point is to help uncover some of the self-evidently “true” presuppositions that we all make when we design. By knowing what we take for granted and knowing also that others work with presup-
positions which may be substantively different from our own, we begin to realize both our ability to exercise choic-
es and our responsibility to think through the conse-
quences of those choices. Each of the approaches is explored as to its ontological, epistemological, value, and methodological presuppositions. Two very direct questions help in this reflection: What relation does the given approach have to the formative conditions of the con-
temporary city? and, How does each of the design approaches relate to the American experiences in thought and action? Prerequisite ARCH-2120. Fall term annually.

This course builds on the content and ideas of ARCH-
2110 and 2120 to examine the history of architecture in medieval and renaissance periods of Western civilization. In doing so it will examine the implications of these develop-
ments for the architecture of later eras as well as the chronology of specific important events in the time period from the 9th to the 17th centuries. Prerequisites ARCH-
2120. Spring term annually.

Design studio introducing students to the processes of crit-
ical inquiry specifically as it relates to architecture investiga-
tions. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are inte-
grated within the work of this studio. Technology 1: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the develop-
ment of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The computer media (3-D modeling “space,” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are inte-
grated in this way with the studio design projects. Drawing: The drawing segment consists of freehand drawing exer-
cises that relate to studio projects and help students devel-
op basic drawing skills and a familiarity with two-dimen-
sional design concepts. Spring and summer terms annually.

Contemporary practices in architecture are examined and used as foils in order to better understand one’s own indi-
vidual approach to design. The point is to help uncover some of the self-evidently “true” presuppositions that we all make when we design. By knowing what we take for granted and knowing also that others work with presup-
positions which may be substantively different from our own, we begin to realize both our ability to exercise choic-
es and our responsibility to think through the conse-
quences of those choices. Each of the approaches is explored as to its ontological, epistemological, value, and methodological presuppositions. Two very direct questions help in this reflection: What relation does the given approach have to the formative conditions of the con-
temporary city? and, How does each of the design approaches relate to the American experiences in thought and action? Prerequisite ARCH-2120. Fall term annually.

Design studio introducing students to the processes of crit-
ical inquiry specifically as it relates to architecture investiga-
tions. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are inte-
grated within the work of this studio. Technology 1: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the develop-
ment of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The computer media (3-D modeling “space,” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are inte-
grated in this way with the studio design projects. Drawing: The drawing segment consists of freehand drawing exer-
cises that relate to studio projects and help students devel-
op basic drawing skills and a familiarity with two-dimen-
sional design concepts. Spring and summer terms annually.

Design studio introducing students from all disciplines to general design through a series of short projects. The proj-
jects stress critical and creative thinking and invention, interdisciplinary collaboration, observation and percep-
tion, communication and visualization. Students will begin open-ended investigations using sketching, photog-
raphy, model making, and computing. Full and summer terms.

A continuation of the pursuit of architecture as critical inquiry within a broad societal context. Instruction inte-
grates considerations of drawing, computers, and construction with design projects. Technology 2: The technology aspects focus on the microclimate and environment context, including shade and shadow analysis, developing skyline plots, and sharing system design and analysis, as well as outdoor environments with emphasis on structure, material, and passive solar systems. Computing: explorations with the computer continue to focus on developing knowledge of 3-D modeling and 2-D image manipulation software and its application to design representations. Computer media are integrated with studio design projects. Drawing: freehand drawing exercises related to studio projects further develop basic drawing skills and familiarly with 2-D design concepts. Prerequisite: ARCH-2210. Full and summer terms annually. 6 credit hours

ARCH-2230 Architecture Design 3
Architecture Design Studio 3 develops practices that focus on the relationship between specific architectural design situations and issues of representation; conceptual, analytical, and critical thinking; ethical dilemmas; and the role that technical issues play in space-making. Prerequisite: ARCH-2220 Architecture Design 2. Spring and summer terms annually. 6 credit hours each

ARCH-2330 Structures 1
Introduction to Structures introduces the student of Architecture to the principles of structural mechanics and their application to basic architectural structures comprised primarily of wood. The fundamentals of statics are presented in order to gain an understanding of the way in which external forces produce internal stresses in individual members and, in essence, flow through the building system to be resolved at the foundation level. The principles of strength of materials are studied to understand how particular structural materials and configurations manage to resist these forces without unacceptable distortions, or even failure. Wood structural properties are studied in all their complexity as a means to internalize the more theoretical topics broached. Through in-class presentations, reading, homework and project work, computer lab, field trips, and case studies the student will be aided in developing this intuitive (while practical) understanding. It is recognized that intuitions of building technologies are not acquired quickly but result from much study, observation, and practice. Introduction to Structures makes use of the several approaches above to ensure that the beginning student is provided with a broad, solid base for future structural investigations. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The following notions are introduced as important attributes of sustainable structures and construction: durability and service life, and life cycle cost. Prerequisites: ARCH-2510 except M.Arch students. Fall term annually. 4 credit hours

ARCH-2350 Construction Systems
Construction Systems centers on the development of a technical knowledge of, sensibility to, and intuition for the process by which an architectural design is realized in built form. The interdependence among building materials, acoustic qualities, enclosure systems, interior, finish, and other systems is investigated, with an emphasis on the broader architectural design endeavor. Drawing as a means of understanding forms the basis for a semester-long project to be done in small groups. Case studies will center on concepts and systems that have not yet found their way into mainstream practice. The course approach will involve in-class presentations, project work, field trips and case studies. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The notion that design intentions can be nullified through incorrect construction is stressed. The importance of proper detailing, construction, and maintenance to accomplish lasting and efficient enclosures is highlighted. Skills to diagnose and treat incorrect construction are developed. Prerequisites: ARCH-2510 except M.Arch students. Fall term annually. 2 credit hours

ARCH-2360 Environmental and Ecological Systems
An exploration of the fundamental principles of human physiology, thermal and luminous comfort, and indoor quality. Emphasis is on bioclimatic and psychrometric climate analysis and its relationship to architectural design, understanding the energy exchange between body in space, the natural meaning of enclosures, and nonstructural materials and systems. The focus is on passive heating, cooling, and daylighting systems and their design. Exercises include vital sign analysis of existing spaces (thermal, air, luminous), forming hypotheses of building performance, using scientific instrumentation, tenant survey techniques, and physical modeling and simulation techniques related to daylighting and shading techniques. Prerequisites: PHYS-1050, ARCH-2220 or permission of instructor. Spring term annually. 4 credit hours

ARCH-2410 Design Drawing
Drawing as the architect's chief design tool and most potent medium of communication. Major ideas about communication, its cultural roots, and its implications for architecture. Demonstrations of and studio practice in graphical techniques used in all phases of the design process, from initial conceptual patterning to final presentation. Drawing exercises in abstracting, symbolizing, behavioral mapping, depicting processes and typologies, expressing spatial character. Prerequisite: at least one year of design studio courses recommended. 4 credit hours
ARCH-2510 Materials and Design
This course establishes an understanding of the most common materials, their properties and resulting uses, and the implications of their uses in the larger context of material life cycles. The structural makeup of metals, ceramics, polymers, and composite materials is discovered and their resulting properties, costs, and life cycle consequences are clarified. An understanding of basic mechanical properties is established hands on by conducting tension, compression, and 3 point bending tests (mse-lab). Physical performance of material constructs as synergy between form and material properties is further illustrated. Experiments are conducted that introduce such major concepts as structural loading, properties of sections, and resulting system performance. Sustainability: The concept of life cycles is introduced; material and energy flows are tracked throughout the entire material life cycle. This will be accomplished alongside introducing major material groupings (metals, polymers, ceramics, and composites). Students come to realize that environmental concerns are directly related to structural composition and material availability. Consequences of resource extraction, distribution, manipulation, use, and disposal, reuse or recycle are addressed at both local and global scales. Selected field trips to materials extraction, processing, manufacturing, disposal, and recycling facilities are aimed to give physical meaning to the concept of life cycle. Spring term annually. 2 credit hours

ARCH-2600 Graduate Design Studio
Design studio introducing students to general design through a series of short projects. The projects stress critical and creative thinking and invention, interdisciplinary collaboration, observation and perception, communication and visualization. Students will begin open-ended investigations using sketching, photography, model making, and computing. Summer and fall terms annually. 6 credit hours each

ARCH-2610 Graduate Architecture Design 1
Design studio introducing students to the processes of critical inquiry specifically as it relates to architecture investigations. These processes are seen as interrelated and always informed by the societal, technological, and historical contexts within which architects work. Parallel instruction in drawing, computing, and construction technology are integrated within the work of this studio. Technology: The technology aspects focus on discovering the basic systems used to create space, such as structural systems, enclosure types, and systems for movement. Emphasis is placed upon constructability and sustainability. These discoveries are through hands-on applications and field visits. Computing: Explorations with the computer focus on both the development of a fundamental knowledge of 3-D modeling and 2-D image manipulation software and a nontraditional application of this knowledge to design representations. The computer media (3-D modeling “space,” computer printouts, video projections) are conceived of as yet another “physical” material for experimentation, and are integrated in this way with the studio design projects. Drawing: The drawing segment consists of freehand drawing exercises that relate to studio projects and help students develop basic drawing skills and a familiarity with 2-D design concepts. Pre-requisite: ARCH-2600. Spring and summer terms. 6 credit hours

ARCH-2620 Graduate Architecture Design 2
A continuation of the pursuit of architecture as critical inquiry within a broad societal context. Instruction integrates considerations of drawing, computers, and construction with design projects. Technology: The technology aspects focus on the microclimate and environment context, including shade and shadow analysis, developing skyline plots, and sharing system design and analysis, as well as outdoor environments with emphasis on structure, material, and passive solar systems. Computing: explorations with the computer continue to focus on developing knowledge of 3-D modeling and 2-D image manipulation software and its application to design representations. Computer media are integrated with studio design projects. Drawing: freehand drawing exercises related to studio projects further develop basic drawing skills and familiarly with 2-D design concepts. Prerequisite: ARCH-2610. Fall and summer terms. 6 credit hours

ARCH-2630 Graduate Architecture Design 3
Graduate Design Studio 3 develops practices that focus on the relationship between specific architectural design situations and issues of representation; conceptual, analytical, and critical thinking; ethical dilemmas; and the role that technical issues play in space-making. Prerequisite: ARCH-2620. Spring and summer terms annually. 6 credit hours each

ARCH-2940 Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students. 1 to 6 credit hours

ARCH-2960 Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires. 1 to 4 credit hours

ARCH-4010 History of Greek and Roman Architecture
A focus on ancient architecture: houses, temples, public buildings, water systems, roads, city walls; methods and elements of city planning, architectural practice, and building methodology; styles and their functional and decorative uses; the influence of Greek and Roman architecture on later periods. A lecture course illustrated with slides. Tests and a research project. Prerequisite: ARCH-2120 or permission of instructor. 4 credit hours
ARCH-4020 Architecture of Early Christian, Byzantine, Romanesque, and Gothic Europe
A focus on European architecture from 330 to 1450 A.D., with a brief look at 19th and 20th century derivatives. Emphasis is on churches, but castles, palaces, monasteries, and town planning are also considered. An illustrated lecture course. Texts and a research project. Prerequisite: ARCH-2120 or permission of instructor. 4 credit hours

ARCH-4030 Architecture and Urban Design of the Italian Renaissance
Organized according to patterns of patronage, architecture and urban design of the 15th and 16th centuries in Italy are studied as a manifestation of the theoretical ideas, sociopolitical context, and historical circumstance of the period. Fall term alternate years. 4 credit hours

ARCH-4040 Cities/Lands
This lecture-seminar is an examination of the parallel historical formation and operation of human settlements together with the territories associated with them, and the interrelations among them in Western Europe, North America, China, the Middle East and North Africa. The purpose is to better understand the role spatial organization plays in the construction of social practices, human subjectivities, and technologies of power. While the differing paradigmatic notions of architectural and landscape practices will be explored in each cultural situation, the emphasis will be on the formative processes operating at all scales and among scales, and the more general design practices that have emerged, and could emerge, from these understandings. Prerequisites: ARCH-2110, ARCH-2120, ARCH-2130, ARCH-2140, ARCH-2230, and ARCH-4140. Spring term annually. 4 credit hours

ARCH-4140 Modernity in Culture and Architecture
An exploration of the idea of modernity as both a cultural phenomenon (extending back to Enlightenment ideas of progress, technological enframing of the world, scientific rationality, historical consciousness, etc.) and as an artistic/architectural discourse unfolding in the 20th century as a radical requestioning of all traditional concepts of program, construction, and aesthetics. As such, this is both a theory and a history course. Prerequisites: ARCH-2120 and ARCH-2130. Spring term annually. 4 credit hours

ARCH-4240 Architecture Design 4
(Studios) An upper level design studio emphasizing the interacting combinations of dynamic influences arising from both global and local scales in the design of portions of the urban landscape, usually including some substantial housing component as well as facilities for the public realm. Prerequisites: ARCH-2230. Fall and summer terms. 6 credit hours.

ARCH-4250, ARCH-4260 Architecture Design 5, 6
A series of upper-level design studios that focus on significant concerns in architecture. Prerequisites: ARCH-4240 for ARCH-4250, ARCH-4250 for ARCH-4260. ARCH-4300 may be taken after ARCH-4250. Fall and spring terms annually. 6 credit hours each

ARCH-4300 Design Development
A technology-based design studio emphasizing the materialization and making of architectural design projects. The integration of building code requirements for fire protection, life safety, accessibility, building environmental systems, structure, construction, and materiality is central to effectively achieving design intent. Students become aware of how these affect and inform design decisions. They learn to integrate technology, systems, and materials in the comprehensive resolution of building design and gain exposure to construction documents and design documentation. Construction and site visits are an integral part of the studio as is an integrated electronic media seminar on CAD applications. Students must coregister for ARCH-4340, a concurrent 2-credit course that introduces codes, the regulatory process, agreements, contract documents, building design cost control, and administration. This course may be taken any time after ARCH-4250. Prerequisites: ARCH-4250, ARCH-4330. ARCH-4740 may be taken as a prerequisite or corequisite. Fall and spring terms annually. 6 credit hours

ARCH-4330 Structures 2
This course builds on the material presented in Structures 1, with an emphasis on the analysis and design of structures compressed primarily of steel and site cast and precast concrete, with an overview of load-bearing masonry and advanced systems. The theoretical concepts covered in the introduction course form the conceptual basis for work in Structures 2, with relevant new concepts/techniques covered. Innovative, non-normative structural systems are investigated and discussed. Analysis and design will proceed using primarily computer-aided techniques. The course approach will involve in-class presentations, homework and project work, computer lab, field trips, and case studies. WebCT will be used to expand the student’s access to course materials and allow for a measure of distance learning. Sustainability: The following notions are introduced as important attributes of sustainable structures and construction: structural robustness, and programmatic flexibility. (Design optimization approaches are introduced and explored as avenues to accomplish more optimum design conditions under increasingly strict design constraints.) Prerequisites: ARCH-2510 except M.Arch students, ARCH-2350, ARCH-2330. Fall term annually. 4 credit hours
ARCH-4360 Graduate Architecture Design 4
(Urban Design Studio) An upper level design studio emphasizing the interacting combinations of dynamic influences arising from both global and local scales in the design of portions of the urban landscape, usually including some substantial housing component as well as facilities for the public realm. Prerequisites: ARCH-2630 Graduate Design Studio 3. Fall and summer terms.

6 credit hours.

ARCH-4420 Digital Media Seminar
This course will explore advanced topics in computer-mediated design processes through both theoretical investigation and hands-on application. Students will investigate the application of video, animation, and/or multimedia technologies to design conceptualization through processes which engage the inherent logics of digital media. Rather than simply employ these technologies, the course will strive to critically examine their implications for architectural designers. Students will complete projects based on past or current design studio work. Prerequisite: ARCH-4240.

4 credit hours.

ARCH-4430 Electronic Media: Physical Design Processes
This course will examine processes of design prototyping and fabrication via 3-D scanning, CNC milling, and other techniques in a critical design context. Two particular foci will be established: the application of these tools as means for physical design visualization of computer-based design work and the exploration of the systemic biases these tools give to the design conceptualization process. In both cases, creative exploration of design opportunity will be encouraged. Students will be expected to create multiple material experiments during the term and will be responsible for purchasing their own materials.

4 credit hours.

ARCH-4460 Electronic Media: Critical Visualization
This course is offered as an advanced design course concerned with the integration of computer modeling, animation, and multimedia technologies into the design methods of the architect. It stresses the need to integrate critical thinking about computer technology and focused learning of software tools and methods. Software used will vary per instructor and will require no previous knowledge of these specific tools. Students, however, should have a fundamental knowledge of and be comfortable with computer systems and operating systems. Some background in computing, for example CSCI-1100, is recommended. Spring term annually. Limited enrollment.

4 credit hours.

ARCH-4510 Construction Industry Seminar
Introduction to the construction industry as an essential context for realizing architecture. A survey of the people, organizations, and professional and industry groups involved in design, construction, finance, insurance, and regulation of building. Current issues influencing design quality are identified by the class and are explored in a series of student-organized in-depth seminars with industry participants. Spring term annually.

2 credit hours.

ARCH-4520 Seminar on Architectural Practice
An examination of contemporary American architectural practice, including an examination of architects, their firms, and professional institutions. Introduction to firm management issues including strategic planning, human resources, marketing and financing, project and risk management. Exploration of the nature of a profession including rights, obligations, and standards of performance.

4 credit hours.

ARCH-4530 Systems Building Seminar
The course focuses on the ways and means by which the building industry and society at large use their resources to plan, design, evaluate, use, and abandon the built environment. It concentrates on the hardware side of the building process, including conventional methods, industrialization, building systems and subsystem approaches, innovative assembly techniques, inventions and innovations, including technology transfers from other industries. Prerequisite: ARCH-4510 or permission of instructor.

Spring term alternate years.

ARCH-4540 Professional Practice
An introduction to architectural practice as related to accomplishing design projects. An overview of professional obligations, registration and conduct, architects’ roles in project delivery, and office organization and management for delivering professional services. In-depth examination of architects’ responsibilities for health, safety, and welfare in design; building code requirements for fire protection, life safety, and accessibility; economics of building systems and assemblies; design and construction contracts; and design documentation. Corequisite: Students in ARCH-4300 Design Development Studio are required to coregister. Fall and spring terms annually.

2 credit hours.

ARCH-4550 Building Economics
An introduction to the economics of building: where the money comes from and where it is spent, factors influencing design and building costs, and approaches to managing costs from initial project definition through construction and use. Techniques for project budgeting, cost estimating, and life cycle cost analysis are included.

4 credit hours.
ARCH-4560 Materials and Enclosures
In a world of rapid technological change, this course aims to equip future architects with the ability to position, understand, and implement new materials and systems in meaningful ways. The working principles of selected advanced materials and systems are explained and issues of material development, applications, and integration into buildings systems are addressed. Emphasis is also placed on understanding the issues involved when combining and installing new materials or systems into buildings. Students are further introduced to detail development. Sustainability: New materials and systems are explored with the objective of formulating meaningful technological response to critical environmental and societal issues such as resource depletion, environmental degradation, and globalization. Prerequisites: ARCH-2510 except M:ARCH students, and ARCH-2350. Spring annually.

ARCH-4610 Building Conservation 1
Investigates the history and use of building materials with special focus on the diagnosis and repair of masonry, wood, metal, and traditional finishes in architecture. Nineteenth century materials will be stressed. Course will involve fieldwork and materials testing laboratory. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 2 credit hours

ARCH-4620 Introduction to Computation-Based Design and Programming
This course offers project-centered training in at least three different design-based programming tool kits. Students will gain a working and applied knowledge of design programming techniques as well as an introductory understanding of the general application of algorithms, automated design systems, and programming languages to architectural design. Offered once annually. Limited enrollment. 4 credit hours

ARCH-4630 Building Conservation 2
Investigates the history and use of 20th century building materials with special emphasis on “modern age” materials such as glass, steel, reinforced concrete, plastic, and other synthetic products. Course will involve fieldwork and materials testing laboratory. Prerequisite: ARCH-4610. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 2 credit hours

ARCH-4640 American Building—17th–19th Centuries
Surveys the forces that shaped American Architecture including European antecedents, social mores, settlement patterns, materials’ availability, technological innovations, stylistic evolution, and prominent practitioners. Significant engineering advances and development of the American landscape will also be discussed. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 2 credit hours

ARCH-4650 American Building—20th Century
Examines the particular forces that have influenced 20th century architecture in America in a worldwide context with emphasis on structural types, materials, and building techniques unknown a century ago. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Prerequisite: ARCH-4640. Spring term annually. 2 credit hours

ARCH-4660 Historical Archeology
Current archeological techniques and approaches to the investigation of historic sites will be taught including historical research and on-site analysis. Course will require fieldwork. Prerequisites: ARCH-6700, ARCH-6680. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 1 credit hour

ARCH-4670 Industrial Archeology
Introduction to America’s great wealth of the 19th and 20th century. Engineering landmarks, particularly those in the Hudson and Mohawk River valleys — their typology and potential for continued and adaptive use, are investigated. Historic bridges and transportation corridors will also be studied. Prerequisite: ARCH-4660. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 1 credit hour

ARCH-4680 Traditional Trades and Craftsmanship
Through hands-on application, students will work with historic building materials to learn traditional construction techniques and crafts. Course will involve fieldwork. Prerequisites: ARCH-4610, ARCH-4630. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 2 credit hours

ARCH-4690 Case Studies: Investigations into Architectural Knowledge
“The best instructor of all...is a building which is being pulled down.” (John Willis Clark, “On the Construction of the Vaults of the Middle Ages,” 1842) Buildings embody cultural knowledge. Their forms and spaces are invested with traces of habitation and beliefs through the employment of materials that are wrought by craft and technology. It is the intention of this course to teach how to investigate buildings in order to reveal the technological and cultural knowledge that is embedded within them. In this course a select number of significant buildings are “disas-
ARCHITECTURE 421

seemed” through intense questioning, and their artificial significance is probed through careful analysis. Prerequisites: ARCH-4560, ARCH-4140, ARCH-4330 and ARCH-4560; A pre- or co-requisite to ARCH-4300. Full term annually. 4 credit hours

ARCH-4700 Advanced Structures and Construction Systems
The development of a working knowledge of building systems comprised primarily of composites, including reinforced, high-strength, and pre-cast concrete, reinforced masonry, and emerging composites. Arches, shells, and plates are analyzed. Advanced computer applications assist the student in developing an understanding of the relationships among concept, material, form, and structural implications. Prerequisites: ARCH-2330. Fall term annually. 4 credit hours

ARCH-4740 Building Systems and Environment
Design analysis and performance characteristics of building environmental systems, emphasizing heating, cooling, ventilation, and lighting systems. In addition, building electrical systems, acoustics, water, waste, and drainage systems are covered in terms of fundamental theory, designs, and calculations. Case studies, field trips, and system design project work are required. Prerequisites ARCH-2360. Spring term annually. 4 credit hours

ARCH-4760 Workshop
This course seeks to cultivate a more explicit understanding of “what is material?” through hands-on experiences with several standard building materials: concrete, steel, wood, etc. The basic characteristics of each material and a few basic techniques for working with each will be presented in discussion and demonstration. Students will work in groups with the given materials on several projects. The ambition of the course is for each student to attain an intuitive understanding of materials through direct experiences with them. Fall and spring terms annually. 4 credit hours

ARCH-4810 Advanced Technology Seminar
Introduction to architectural research and emerging technologies as an essential component for changing architecture. A survey of people and organizations involved in research, design, prototyping, and use of emerging technologies. The emphasis is on exploring how emerging technologies impact architectural design and construction. Current issues and ideas are identified by the class and are explored in a series of student-organized in-depth seminars with leading designers, scientists, and inventors. Fall term annually. 2 credit hours

ARCH-4840 Architectural Acoustics 1
This course provides an overview of the essentials for architectural acoustics design of performance and public spaces, including concert halls, theaters, museums, classrooms, sports arenas, courtrooms, and religious buildings. There are no prerequisites, but the course may be used as the starting point for a certificate in Architectural Acoustics, a concentration in an architecture student’s professional electives, or the beginning of a master’s degree in acoustics. The course covers basic principles of sound, room acoustics, sound absorption in rooms, sound isolation and privacy, acoustics of mechanical systems, and sound quality. After both Architecture Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture or in acoustical consulting. Fall term annually. 4 credit hours

ARCH-4850 Architectural Acoustics 2
In the spring semester, students will have the opportunity to design their own performance hall. This process will include continued studies of acoustics measurements, simulated sound fields, community noise issues, and professional practice in acoustics consulting. The course will also have detailed lectures on concert hall acoustics, sound quality, and synthesized sound fields. Students will be introduced to a variety of simulation software and measurement equipment in the Acoustics Research Laboratory. After both Architectural Acoustics 1 and 2, the student should be prepared for a basic entry-level position in either acoustics in architecture, or in acoustical consulting. Prerequisite: ARCH-4840 or instructor approval. Spring term annually. 4 credit hours

ARCH-4940 Advanced Individual Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students at the advanced level. 1 to 6 credit hours

ARCH-4960 Special Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires. 1 to 4 credit hours

ARCH-4980 B.Arch. Final Project 1
An individually initiated, planned, and developed comprehensive project that creatively engages the material inhabited world. The semester begins with a 5-week architecture competition and includes a research/methods seminar that is common to all students. The competition is followed by an integrated design research phase under the guidance of a final project adviser and two reviewers. In that phase, each student initiates, prepares, and develops a project for completion in ARCH-4990. For students in the B.Arch. program only. Fall and spring terms annually. 6 credit hours

ARCH-4990 B.Arch. Final Project 2
The final phase of B.Arch. students, final project — a comprehensive investigation that engages the material inhabited world. The students continue and complete the integrated design research phase of an approved project
ARCH-6110 Design Explorations 1
Case Studies – Investigations Into Architectural Knowledge. Selective architectural works will be deconstructed in order to uncover the knowledge invested in them. Case studies will be subjected to modes of inquiry that will reveal their deep content from conception to realization, including the mental frameworks of the designers, the methods of representation, the technological knowledge employed, the methods of production, and the ingrained cultural values, to develop methods of inquiry that will enable them to pursue similar investigations of any architectural work. Fall term annually. 6 credit hours

ARCH-6110 Design Explorations 2
The study of the work and ideas of an architect who was an active part of an exceptional cultural situation. For example, in past years the work and ideas of Adolf Loos have been studied in relation to the context of his fin-de-siècle Vienna. Prerequisite: ARCH-6110 or permission of instructor. Spring term annually. 4 credit hours

ARCH-6130 Design Explorations 3
Architectural situations are studied in situ by making field trips to them and engaging in various critical and analytical design studies of them. For example, in past years this course has examined the lifework and theories of the architect Le Corbusier, focusing on his Carpenter Center for the Visual Arts. Prerequisite: ARCH-6110 or permission of instructor. Fall term annually. 4 credit hours

ARCH-6210, ARCH-6220 Graduate Studio 1, 2
Individual and group projects conducted within the framework of a preselected problem area (or number of problem areas). Individual students pursue specialized elements or aspects of the problem area with emphasis on revealing a deeper knowledge of the parts. Group activity centers on discussions of individual contributions and emphasizes the role of these contributions as they build a greater understanding of the total problem area. For students in the M.Arch. second professional degree program and M.S. in Building Sciences program only. 2 to 7 credit hours

ARCH-6400 Philosophies of Space in a Digital Culture
The focus of the course will be on establishing an intellectual means to comprehend the cultural context of electronic media. The course will examine relevant philosophies, psychologies, and cultural ephemera to situate the ‘information revolution’ into a meaningful context. The motivations of the class are very political; architecture (via an expanded definition) is seen as a means of comprehending the powers of space and nonspace. Electronic media and its related technologies will be examined through the filter of a theory of architecture — a theory that will be designed throughout the course. Fall terms annually. Limited enrollment. 6 credit hours

ARCH-6420 Experimental Research Lab
This course is offered primarily to familiarize students in the Informatics and Architecture post-professional master’s program with facilities and technologies significantly relevant to a technologized practice of architectural design. The course is composed of introductory training sessions in a variety of laboratories and studios to expose students to the techniques available to them in their design pursuits. Offered once annually. Limited enrollment. 4 credit hours

ARCH-6440 Simulation
Covering first the theoretical ground for visual and performative architectural simulations, this course will introduce students to the methods of three primary types of simulation: visual simulation or visualization, interactive simulation, and performative or mathematical simulation. The course will stress the simultaneous critical investigation into and application of simulation tools and techniques to conceptual problems of architecture and urbanism. Offered once annually. Limited enrollment. 4 credit hours

ARCH-6460 Stagecraft and Theater Design 1
This course introduces students to the elements of theater design and construction. The course will discuss the physical structures in which the theater evolved as well as on the social, political, and economic forces that are associated with the theater’s different historical periods. Particular emphasis is given to understanding historical methods of stagecraft and their relation to modern construction techniques and use of materials. Prerequisites: instructor approval for undergraduates. Fall term annually. 4 credit hours

ARCH-6470 Stagecraft and Theater Design 2
The course will develop in greater depth the concepts and design practices from Stagecraft and Theater Design 1. Significant emphasis will be placed on optimal construction design and techniques of components of stage sets. In addition, the course will discuss acoustical considerations for theater and stage shell design. Prerequisites: ARCH-6460 or instructor approval. Spring term annually. 2 credit hours

ARCH-6610 Preservation Theory
Examines the historical foundation of the roughly 200-year-old historic preservation movement and the various philosophies which presently motivate it. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 1 credit hour
ARCH-6620 Contemporary Preservation Practice
Visits to and from architectural firms. Investors, developers, government officials, and not-for-profit executives will introduce students to opportunities in contemporary preservation practice and what potential employers are seeking. An extensive range of disciples will be explored including urban planning and landscape design. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 1 credit hour

ARCH-6630 Economics of Historic Preservation
Discusses the impact of preservation projects in a community and the tools for funding them. Investigation into private sources, i.e., foundation and not-for-profit grants; public grants, incentive, and loan programs; impact on tourism and business revitalization; and instructions on how to approach funding sources and measure economic strides. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 1 credit hour

ARCH-6640 Historic Preservation Law
Analysis of federal, state, and local laws affecting historic resources — from implementation of the National Historic Preservation Act to enactment of local legislation. Included will be related federal and state regulations on land use and environmental protection. Code, public health, and zoning issues will also be investigated. Prerequisites: ARCH-6630 and ARCH-6610. Meets on alternate Friday and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 1 credit hour

ARCH-6650 Architectural Materials Testing
A course in conjunction with Building Conservation 1 and 2 to provide in-depth laboratory work on the performance and durability of historical architectural building materials. Strength, fire resistance, and other code-related properties will be tested and judged against contemporary standards. Course will involve materials testing laboratory. Prerequisites: ARCH-4640, ARCH-6610, ARCH-4610, and ARCH-6700. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 2 credit hours

ARCH-6670 Structural and Mechanical Systems
Historical structural and mechanical systems will be studied. Building code issues will be explored along with innovative and discrete methods of heating, cooling, ventilating, and lighting historic buildings. Prerequisite: ARCH-4610. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 1 credit hour

ARCH-6680 Researching Historic Structures
How to investigate an historic structure based on public and private archival records and published sources that include written, graphic, photographic, and oral materials. In conjunction with Recording Historic Structures, this course will teach students how to “read” a building and produce an historic structures report. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 4 credit hours

ARCH-6690 Drawing Historic Structures
An introduction or remedial course in free-hand drawing as a way of looking at, imagining, and presenting historic buildings. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Fall term annually. 1 credit hour

ARCH-6700 Recording Historic Structures
How to record and interpret according to current standards of architectural documentation the physical structure, condition, and historical changes to existing buildings using non-destructive traditional methods and newly adopted probes. Architectural photography, photogrammetry, and computer realization will be studied. Course will involve fieldwork, will meet on alternate Fridays, and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 2 credit hours

ARCH-6710 Preservation Design Studio 1
Working in teams of four to six, students will take on the complete documentation and analysis of a particular building or discrete group of historic structures. Included will be preparation of an historic structures report and feasibility plans for the continued or renewed vitality of the structure. Retrofitting and adaptive use will be part of the discussion. Prerequisites: ARCH-4640, ARCH-6610, ARCH-6610, and ARCH-6700. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 4 credit hours

ARCH-6720 Preservation Design Studio 2
Serving as a cumulative project each student will undertake a community/neighborhood preservation project working with local partners and sponsors including public officials, not-for-profit organizations, historical societies, business improvement districts, owners, and advocacy groups among others. Projects will be approved by the faculty adviser and program director. Recording, research, legal and economic analysis, proposal preparation, and fund-raising skills will all be brought to bear on the project. Prerequisites: ARCH-6710. Meets on alternate Fridays and Saturdays and is limited to students in the Building Conservation Program or by special permission. Spring term annually. 4 credit hours
ARCH-6810 Research Design Seminar
The principal objective of this seminar is to provide students with the opportunity to learn the fundamentals of research design. Research design includes: 1) identifying and selecting focused research problems/opportunities/ideas; 2) documenting the state of the art in the selected research area; 3) identifying the critical resources and settings to carry out the research; 4) designing the research program including strategies and tactics for carrying out the research. It is hoped that the knowledge gained in the RD Seminar will assist students in the development of their own individual thesis proposals. Fall term annually. 2 credit hours

ARCH-6870 Sonics Research Laboratory I
The Sonics Research Lab is completely research based. First, we will develop an understanding of the measurement equipment and analysis required in order to quantify qualitative aspects of various sonic environments. In addition, we will examine the ISO standards for measurements in order to develop specific research goals. Students and professors will travel to a performance hall and perform measurements. Students will then analyze the data and interpret the results. Dissemination of results will go toward furthering the practice of architectural acoustics and increasing the understanding of the resultant subjective quality of a room. Co-requisites: ARCH-4840 or instructor approval. Fall term annually. 4 credit hours

ARCH-6880 Sonics Research Laboratory II
The second semester of the Sonics Research Lab focuses on predictability models and virtual acoustics “auralization.” State-of-the-art software will be used for simulation of room acoustics in order to show the student how such programs assist in refining the design of performance and public spaces. Prerequisites: ARCH-6870 or instructor approval. Spring term annually. 2 credit hours

ARCH-6900 Graduate Thesis Seminar
Readings and discussion of topical materials that are selected to place graduate projects and theses in a comprehensive context. Fall and spring terms. 2 credit hours

ARCH-6940 Advanced Individual Projects in Architecture and Environmental Design
Individual projects and readings adapted to the needs of individual students at the advanced level. 1 to 6 credit hours

ARCH-6960 Special Topics in Architecture and Environmental Design
Experimental courses tried out in one or two terms as the general program requires. 1 to 4 credit hours

6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ARCH-6980 Master's Project
Active participation in a master's level project, under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. Grades will then be listed as S. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the library. 1 to 9 credit hours

ARCH-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

ARTS Arts (HSSH)

ARTS-1010 Media Studio: Video/Audio
This class is an introduction to the technical and conceptual foundations of video and audio media art forms. Students learn basic recording and editing techniques and develop critical listening and viewing skills. Individual and group projects are created and critiqued in class with a final public presentation of work at the end of the semester. Fall and spring terms annually. 4 credit hours

ARTS-1020 Media Studio: Imaging
An introductory course exploring digital photography, Web design, and interactive multimedia in making art. Students broaden their understanding of the media and expand visual awareness and design skills. Inquiry and experimentation are encouraged, leading towards the development of the skills and techniques needed to create visual art with electronic media. Fall and spring terms annually. 4 credit hours

ARTS-1200 Basic Drawing
An introductory course in drawing designed to develop seeing ability and means of expressing visual ideas through graphic skills. The course consists of exercises in drawing from observation and studies from the history of art. Fall and spring terms annually. 4 credit hours
ARTS-1400 Music Fundamentals
A creative approach for students with no previous experience to the concepts of music theory (rhythm, scales, keys, intervals, chords, etc.) and elementary harmony. Also an introduction to some of the monuments of Western repertory through listening, reading, and discussion. Spring term annually. 4 credit hours

ARTS-2010 Intermediate Video
This course explores contemporary video practice, concentrating on creating, presenting, and analyzing video art. It is an introduction to the Arts Department production facilities and equipment, and a prerequisite for 4000-level video classes. Prerequisite: ARTS-1010 or permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-2020 Computer Music
Music composition taught in the context of modern computerized production methods. Technical topics include basic principles of computer sound generation, digital sound sampling, and the use of small computers for musical control of electronic instruments. Musical topics include a study of important musical works and compositional techniques of the 20th century. Student projects involve hands-on work on a variety of computer instruments and software. This course is a prerequisite for further creative work with Rensselaer’s computer music facilities. Prerequisite: ARTS-1010 or permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-2030 Net Art
Net Art is a hands-on studio course that uses the examination of the historical and theoretical aspects of Web-based art and virtual social spaces as a launching pad for individual student work. Considerable work at the conceptual level and a survey of Web-oriented software and programming enable students to create new works in net-based art. Prerequisite: ARTS-1010 or permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-2040 Intermediate Digital Imaging
Intermediate Digital Imaging is a hands-on studio course exploring the use of computer technologies in making visual art. A study of contemporary issues in digital media and photography facilitates individual innovation and experimentation. Digital imaging and input/output techniques are employed in terms of giving visual form to ideas and personal expression in private and public settings. Prerequisite: ARTS-1020 or permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-2100 Television and Culture
This lecture course will examine selected topics of historical and contemporary television, alternative TV, interactive experiments, and video art. The class consists of video screenings, readings, and discussion. Prerequisite: First year studies or permission of instructor. 4 credit hours

ARTS-2210 Sculpture I
A beginning sculpture course combining hands-on studio work sessions with lectures on the history and theory of sculpture practice. The studio component involves explorations of materials and techniques as tools for the enhancing of visual sensitivity and creative expression. Fall and spring terms annually. 4 credit hours

ARTS-2220 Fundamentals of 2-D Design
An introductory course which will present basic concepts about composition, line, pictorial space, light, and color in the visual arts in order to help students develop the means for expressing visual ideas effectively. Weekly homework design projects, using both traditional and electronic media, will be complemented by in-class slide lectures, video tapes, and critiques. Fall and spring terms annually. 4 credit hours

ARTS-2300 Rensselaer Orchestra
Readings, rehearsals, and performances of works from the standard repertoire for orchestra from the Baroque through the 20th century. Prerequisite: demonstration of adequate skill in playing an orchestral instrument through audition. Fall and spring terms annually. 1 credit hour

ARTS-2310 Rensselaer Concert Choir
Readings, rehearsals, and performances of works from the standard choral repertoire, from the Renaissance through the 20th century. Attendance is mandatory and preparation expected. Fall and spring terms annually. 1 credit hour

ARTS-2330 Ghanaian Drumming Ensemble
This course uses traditional Ghanaian drumming to explore the intricate and complex rhythms which permeate Ghanaian history and culture. Classes consist of lecture, demonstrations, discussions, and practical application of technique, individually and in groups. Fall and spring terms annually. 1 credit hour

ARTS-2400 Music Theory I
A course that explores the fundamental concepts of music theory, for the students with at least some musical background. Rhythm, scales, keys, intervals, chords, and elementary harmony will be covered as well as an introduction to counterpoint and analysis. Correlative studies in ear-training and keyboard skills. Fall term annually. 4 credit hours

ARTS-2500 History of Western Music
The objective of this course is for students to be able to recognize and appreciate the stylistic elements of the major periods and composers from the earliest known music to the present. The influences on music by broad cultural and historical forces will also be explored. Beginning with the Greeks, we will progress chronologically from the polyphonic religious music of the Middle Ages through the Renaissance, Baroque, Classical, Romantic, and modern periods. Fall term annually. 4 credit hours
ARTS-2510 History of Jazz
Using rare film and video footage as well as records, CDs, texts, and live musicians, this course traces the development of jazz over its century of existence. Fall term annually.  

4 credit hours

ARTS-2540 The Multimedia Century
This course will survey the history and theory of the diverse artistic practices of the twentieth century in relation to the development of the mass media and new technologies. Topics will include the Bauhaus, Surrealism, Pop Art, and Postmodernism and will span a spectrum of media from the more traditional, such as painting and photography, to electronic and new media, such as video and digital arts. Fall term annually.  

4 credit hours

ARTS-2560 The American Musical
This course surveys the American Musical, introducing students to its basic components and concepts. Since the musical integrates different media, it is studied through the contribution of major artists as well as in historical, social, and cultural contexts. The course also analyzes music and musical theater genres, which influenced the musical, including European opera and operetta; American blues, ragtime, and jazz; and Latin-American rhythms. No prerequisites. Fall term annually.  

4 credit hours

ARTS-2600 Acting I
This course introduces students to the principles of acting. Students participate in theatre games and improvisations; explore the stage environment; study dramatic conflict and transformation into different characters; and learn stage terminology and blocking. The emphasis is on individual and group projects that develop students’ creativity and imagination. The culmination of the course is the presentation of monologues and scenes from international plays. Fall term annually.  

4 credit hours

ARTS-2940 Studies in the Arts
Projects adapted to the needs of individual students.  

1 to 4 credit hours

ARTS-2960 Topics in the Arts
Experimental courses offered for one or two terms as the general program requires.  

2 to 4 credit hours

ARTS-4020 Advanced Digital 3-D Projects
Advanced Digital 3-D Projects is a studio/seminar in the arts concentrating on individual student projects in advanced digital 3-D research. Topics covered include issues in virtual environment creation, human interface to 3-D data, digital sculpture, advanced animation research, and others. Newly emerging issues in digital 3-D as they apply to art theory and practice will be addressed. Prerequisites: ARTS-2030, or ARTS-4060, ARTS-4070, or permission of instructor. Spring term annually.  

4 credit hours

ARTS-4030 Virtual Environments/3-D Web
An upper level studio arts course exploring the visualization and creation of interactive three-dimensional simulated environments for the Web and for art installation. The course addresses newly emerging issues in virtual simulation as they apply to art theory and practice. Prerequisite: ARTS-1020 or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4050 Arts Practicum
Arts Practicum provides professional training and experience for graduates and upper-level undergraduates by involving them in the production of a significant artistic project from start to finish. Projects often involve assisting or collaborating with prominent artists in residence at the iEAR studios. Prerequisites: graduate standing, or two 2000-level electronic arts courses, or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4060 Animation I
An introduction to the techniques and principles of computer animation with a concentration on modeling, texturing, and rendering. Students use advanced software to develop directed creative 3-D animations in a hands-on studio. Lectures, discussion, and exposure to contemporary work enable students to develop skills in this rapidly evolving field. Prerequisite: 2000-level electronic arts course or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4070 Animation II
An intermediate hands-on studio course in 3-D computer animation in basic character animation, advanced modeling and particle animation, scene description and story building. Prerequisite: 2000-level electronic arts course or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4010 - Interactive Arts Programming
IAP will examine theoretical concepts of interactive media as well as develop the practical skills needed to implement these concepts using the facilities of the iEAR studios. Topics include high and low level computer programming and electronics. We will build installations, and projects which control live performance interactions with graphics, video, and sound. Prerequisites: Computer Music or Video Art and Installation or permission of the Instructor. Spring term annually.  

4 credit hours

ARTS-4030 Virtual Environments/3-D Web
An upper level studio arts course exploring the visualization and creation of interactive three-dimensional simulated environments for the Web and for art installation. The course addresses newly emerging issues in virtual simulation as they apply to art theory and practice. Prerequisite: ARTS-1020 or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4050 Arts Practicum
Arts Practicum provides professional training and experience for graduates and upper-level undergraduates by involving them in the production of a significant artistic project from start to finish. Projects often involve assisting or collaborating with prominent artists in residence at the iEAR studios. Prerequisites: graduate standing, or two 2000-level electronic arts courses, or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4060 Animation I
An introduction to the techniques and principles of computer animation with a concentration on modeling, texturing, and rendering. Students use advanced software to develop directed creative 3-D animations in a hands-on studio. Lectures, discussion, and exposure to contemporary work enable students to develop skills in this rapidly evolving field. Prerequisite: 2000-level electronic arts course or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4070 Animation II
An intermediate hands-on studio course in 3-D computer animation in basic character animation, advanced modeling and particle animation, scene description and story building. Prerequisite: 2000-level electronic arts course or permission of instructor. Fall and spring terms annually.  

4 credit hours

ARTS-4030 Virtual Environments/3-D Web
An upper level studio arts course exploring the visualization and creation of interactive three-dimensional simulated environments for the Web and for art installation. The course addresses newly emerging issues in virtual simulation as they apply to art theory and practice. Prerequisite: ARTS-1020 or permission of instructor. Fall and spring terms annually.  

4 credit hours
ARTS-4120 Radio: Theory and Practice
This course is an investigation of radio as a unique artistic form. To provide a context for student’s own production work (which will be aired over WRPI) the class incorporates readings on aesthetics, culture, history, politics, and economics of the world’s first electronic broadcast technology. Prerequisite: ARTS-1010, COMM-1510. Fall and spring terms annually. 4 credit hours

ARTS-4200 Advanced Drawing
Advanced Drawing is designed to help students who have mastered basic drawing skills to enhance those skills and utilize them to explore visual ideas. Emphasis is placed on individual development of skills and subject matter to help students express themselves visually. Examples and studies are used from master drawings of the past to learn about the history of art and to stimulate ideas for the students’ own work. Prerequisite: ARTS-1200 or permission of instructor. 4 credit hours

ARTS-4210 Sculpture 2
An advanced studio course in sculpture for students who have taken Sculpture I. Students are encouraged to explore personal areas of interest and are required to develop a familiarity with the history of sculpture as well as mastering fabrication techniques. Prerequisite: ARTS-2210. Offered on availability of instructor. 4 credit hours

ARTS-4220 Painting
A painting course in water media with emphasis on color interaction, composition, and pictorial design. Using sources from observation and the history of painting, students are taught to see and convey effects of color on/in 2-D pictorial space and to develop critical skills in looking at paintings. Prerequisite: ARTS-1200. 4 credit hours

ARTS-4400 Music Theory II
A continuation of studies in harmony, analysis, and ear-training. With an introduction to orchestration and 20th century techniques, the course will culminate with an original composition. Prerequisite: ARTS-2400. Spring term annually. 4 credit hours

ARTS-4620 Theatre Performance
This course gives students a practical background in the field of theatre, introducing them to all aspects of a theatre production. Students rehearse a play in the classroom and then give performances on the RPI campus. Students also participate in directing, stage managing, writing press releases, and designing set, costumes, lighting, and sound for the show. Auditions take place on the first day of class. Fall term annually. 4 credit hours

ARTS-4710 Technical Production and Documentation
This course teaches the skills needed to produce and document professional electronic arts events, including live concerts, installations, and multimedia presentations. It is an intensive, hands-on course designed to give students direct experience with sound, video, and lighting equipment in live performance environments. Students will learn technical and creative skills essential for artistic practice in the field of electronic arts. Prerequisite: limited to upper class B.S. EARTS, EMAC, IT ARTS students, MFA students, or by permission of instructor. Fall and spring terms annually. 4 credit hours

ARTS-4910 EMAC Capstone Design
EMAC Capstone Design is a two-semester sequence offered in fall and spring and is required for graduating seniors majoring in EMAC. Through a series of production and writing assignments, breakout seminars, group critiques, and public exhibition, the goal is to develop a work-in-progress in the fall semester and a final version in the Spring semester of the capstone project and senior thesis paper. Both Arts and Communications sections are team-taught by faculty from the Arts and LL&C Departments. (This course is cross listed with COMM-4910. Students cannot receive credit for both this course and COMM-4910.) Fall and spring terms annually. 2 credit hours

ARTS-4940 Studies in the Arts 1 to 4 credit hours
ARTS-4960 Topics in the Arts 3 to 4 credit hours
ARTS-6010 Computer Music Studio
An introduction to the history, theory, techniques, and practice of computer music composition with an emphasis on hands-on creative work. This course functions as an orientation for incoming MFA students to the musical resources of the iEAR studios. Students use the studio facilities to produce directed creative projects. Prerequisite: limited to MFA students or permission of instructor. Fall term annually. 4 credit hours

ARTS-6020 Video Art Studio
An introduction to techniques and principles of video art preproduction, production, and post-production, with an emphasis on hands-on creative work in the iEAR Studios. Studies include historical and theoretical analysis of important works and techniques of video art, practical technical instruction, performance, and directed creative projects. Prerequisite: enrollment in the MFA program or permission of instructor. Studio course. Fall term annually. 4 credit hours

ARTS-6030 Digital Imaging Studio
This graduate studio course embarks on the exploration of the computer as an agent to augment and expand conceptualization and expression in art-making. The techniques and principals of digital imaging are developed with an emphasis on conceptual, aesthetic, and critical issues relating to content. Prerequisite: limited to MFA students or permission of instructor. Fall term annually. 3 credit hours
ARTS-6080 Electronic Arts Practice
Development and completion of individual creative projects in electronic arts with discussions and critiques of student work in a seminar format. Projects may use any of the studios and combinations of media available in the iEAR Studios. All projects will be presented or performed in public concerts, exhibitions, and installations. Prerequisite: limited to MFA students in electronic arts. Fall and spring terms annually. 3 credit hours each

ARTS-6110 Electronic Arts Overview
This seminar will deal with the history, theory, and creation of art, popular culture, and mass media from a contemporary perspective. Theoretical and historical texts and a spectrum of electronic arts and media will be investigated. This course is to be taken in conjunction with Creative Seminar I. It will support the students' development and articulation of the aesthetic, cultural, and theoretical underpinnings of their artistic work produced in ARTS-6080 and in other studio courses. Prerequisite: limited to MFA students or permission of instructor. Fall term annually. 3 credit hours each

ARTS-6940 Studies in Electronic Arts
Individual and collaborative projects and readings adapted to the needs of individual students at the advanced level. Fall and spring terms annually. 4 to 8 credit hours

ARTS-6960 Topics in Electronic Arts
3 to 6 credit hours

ARTS-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

ASTR Astronomy (SOS)

ASTR-1510 Quasars and Cosmology
An introduction to the origin and large-scale structure of the Universe. Topics to be covered include: the contents and geometry of the Universe, the Big Bang model, particle physics and the formation of the elements, galaxy formation, dark matter, black holes, and active galactic nuclei. If ASTR-1510 is taken as a 1-credit course, it will be graded satisfactory/unsatisfactory, and it cannot be counted towards the Institute's baccalaureate requirement of 24 credits in the sciences. If ASTR-1530 is taken as a 2-credit course, it will be graded in the conventional manner. If ASTR-1530 is taken as a 1-credit course, it will be graded in the conventional manner. If ASTR-1510 and ASTR-1530 are both taken as graded 2-credit courses, they may be counted together as one 4-credit elective for nonscience majors. Fall term annually. 1 or 2 credit hours

ASTR-1530 Tour of the Solar System
A survey of the solar system based on recent results from ground-based observations and space probes. Topics to be covered include: the sun, moon, Venus, Mars, the giant planets, comets, and the search for life in the solar system. If ASTR-1530 is taken as a 1-credit course, it will be graded satisfactory/unsatisfactory, and it cannot be counted towards the Institute's baccalaureate requirement of 24 credits in the sciences. If ASTR-1530 is taken as a 2-credit course, it will be graded in the conventional manner. If ASTR-1510 and ASTR-1530 are both taken as graded 2-credit courses, they may be counted together as one 4-credit elective for nonscience majors. Spring term annually. 1 or 2 credit hours

ASTR-1960 Topics in Astronomy and Astrophysics
1 credit hour

ASTR-2050 Introductory Astronomy and Astrophysics
Astronomy for students with a background of college mathematics and physics. Topics include: astrophysical concepts, solar system basics, stellar astronomy and the interstellar medium, the Milky Way system, galaxies, quasars, and cosmology. Prerequisites: MATH-1020 and PHYS-1200. Spring term annually. 4 credit hours

ASTR-2120 Earth and Sky
An introduction to astronomy from an observational perspective. Students will learn the basics of observing the night-time sky, both with the unaided eye and through telescopic observation. Observations of Earth from orbiting satellites will also be discussed. The course is suitable for nonphysics and nonscience majors as well as those committed to specialization in Astronomy. Includes evening laboratory sessions. Fall term annually. 4 credit hours

ASTR-2940 Special Projects in Astronomy
Study and research in various fields of astronomy to demonstrate interest in and ability for independent work. Prerequisite: permission of instructor. Fall and spring terms annually. 3 credit hours

ASTR-4120 Observational Astronomy
An introduction to astronomical observing techniques and instrumentation. Optical telescope design. Observatory site selection. Telescopes above the atmosphere. Imaging techniques: photography, charge-coupled devices. Optical photometry, spectroscopy and polarimetry, and their applications. Infrared techniques and applications. Radio astronomy. Includes evening laboratory sessions. Prerequisite: ASTR-2050 or permission of instructor. Fall term annually. 4 credit hours

ASTR-4220 Astrophysics
A survey course in modern astrophysics with an emphasis on stellar astrophysics and interstellar matter; Topics include star formation, the structure and observable prop-
Astronomy courses offer a wide range of topics, from the origin of life to the dynamics of the interstellar medium. Here are some highlights:

- **ASTR-4230 Frontiers in Astrophysics**: An in-depth treatment of topics of current interest in astrophysics. The topic(s) selected may vary with each offering. Examples include galactic dust, astrophysical radiation hydrodynamics, physics of star formation, galactic dynamics. Students cannot obtain credit for both this course and ASTR-4250. Prerequisite: ASTR-4220. Spring term alternate years. 4 credit hours

- **ASTR-4240 Gravitation and Cosmology**: Introduction to the physics of gravitation and spacetime with an emphasis on cosmological applications. Special relativity, tensor calculus, and relativistic electrodynamics. Einstein's field equations and testable predictions. Gravitational lensing. Gravitational radiation. The physics of black holes. The Big Bang model of the Universe and relevant observations. Prerequisite: PHYS-2330 or permission of instructor. Spring term annually. 3 credit hours

- **ASTR-4250 Interstellar Medium**: Thermal structure and dynamics of the interstellar medium. Topics include diffuse nebulae, composition of interstellar dust and relation to extinction and polarization, molecules and interstellar chemistry, physics of star-forming regions. Students cannot obtain credit for both this course and ASTR-6250. Prerequisite: ASTR-4220. Fall term alternate years. 4 credit hours

- **ASTR-4510 Origin of Life: A Cosmic Perspective**: To understand the origin of life is a fundamental goal of science. We discuss evidence for important prebiotic molecules in the clouds from which new planetary systems are born, and compare cosmic and terrestrial sources of such molecules on the primitive Earth. The course is multidisciplinary, covering topics in physics, astronomy, chemistry, earth sciences, and biology. Prerequisite: ASTR-2050 or permission of instructor. Spring term annually. 4 credit hours

- **ASTR-4900 Astrophysics Undergraduate Seminar**: Discussion of topics in the current astrophysical literature. Each student is required to give one oral presentation based on a paper or group of papers. Prerequisite: junior standing or higher, or permission of instructor. Fall and spring terms annually. 1 credit hour

- **ASTR-4940 Special Projects in Astronomy**: Study and research in various fields of astronomy to demonstrate interest in and ability for independent work. Prerequisite: permission of instructor. Fall and spring terms annually. 3 credit hours

- **ASTR-4960 Topics in Astronomy and Astrophysics**: An in-depth treatment of topics of current interest in astrophysics. The topic(s) selected may vary with each offering. Examples include galactic dust, astrophysical radiation hydrodynamics, physics of star formation, galactic dynamics. Students cannot obtain credit for both this course and ASTR-4230. Prerequisite: ASTR-4220. Spring term alternate years. 4 credit hours

- **ASTR-6230 Frontiers in Astrophysics**: An in-depth treatment of topics of current interest in astrophysics. The topic(s) selected may vary with each offering. Examples include galactic dust, astrophysical radiation hydrodynamics, physics of star formation, galactic dynamics. Students cannot obtain credit for both this course and ASTR-4230. Prerequisite: ASTR-4220. Spring term alternate years. 3 credit hours

- **ASTR-6250 Interstellar Medium**: Thermal structure and dynamics of the interstellar medium. Topics include diffuse nebulae, composition of interstellar dust and relation to extinction and polarization, molecules and interstellar chemistry, physics of star-forming regions. Students cannot obtain credit for both this course and ASTR-4250. Prerequisite: ASTR-4220. Fall term annually. 3 credit hours

- **ASTR-6900 Astrophysics Seminar**: Discussion of topics in the current astrophysical literature. Each student is required to give an oral presentation based on a paper or group of papers. For graduate students only. Fall and spring terms annually. 1 credit hour

- **ASTR-6940 Readings in Astronomy and Astrophysics**: Supervised reading and study in various fields of astrophysics. 3 credit hours

- **ASTR-6960 Special Topics in Astronomy and Astrophysics**: Supervised reading and study in various fields of astrophysics. 3 credit hours

- **6970 Professional Project**: Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser; listing the work remaining to be completed and the time limit for completing this work.

---

**BCBP Biochemistry and Biophysics (SOS)**

- **BCBP-2900 Research in Biochemistry/Biophysics**: Hands-on research in a faculty member’s research laboratory. Prerequisite: permission of instructor. Offered each term. 3 to 4 credit hours, 9 to 12 contact hours
BCBP-2930 Out-of-Classroom Experience in Biochemistry/Biophysics  
Credit to be given for an out-of-classroom experience related to biochemistry and/or biophysics (BCBP) having intellectual content relevant to the student’s educational or career goals, subject to approval of a written proposal and a final written report. The adviser (for BCBP majors) or, with permission, any BCBP faculty member may serve as evaluator. For each out-of-classroom experience a student may register only once.  
1 to 4 credit hours  

BCBP-2940 Readings in Biochemistry/Biophysics  
Independent study of selected readings in the fields of biochemistry and biophysics, supervised by a faculty member. Prerequisite: permission of instructor. Offered each term.  
1 to 4 credit hours  

BCBP-2990 Research Thesis  
Independent research, supervised by a faculty member, culminating in a written thesis. Prerequisite: permission of instructor. Offered each term.  
3 to 4 credit hours, 9 to 12 contact hours  

BCBP-4210 Biophysical Methods  
Topics covered will include electron microscopy of ordered samples, structural databases, hydrodynamics of biological macromolecules, viscosity, sedimentation, translational and rotational diffusion, chromatography, conductance, dielectrophoresis, dynamic light scattering, flow and electric birefringence, and electrophoresis. Also water as a solvent, polyelectrolytes, and Debye-Huckel theory. (Students may not receive credit for both BCBP-6210 and BCBP-4210.) Prerequisite: CSCI-1100, BIOL-2120, CHEM-2440, or PHYS-1100 or equivalents. Spring term odd-numbered years.  
4 credit hours  

BCBP-4310 Genetic Engineering  
Case studies on the effect of genetic engineering on medicine, agriculture, biology, forensics, and various other areas of technology. Each week a set of assigned readings will be discussed. Some of the topics to be covered are vaccines, biomolecular computing and electronics, paleontology, ecology, bioremediation, and polymers. (Students cannot obtain credit for both this course and BCBP-6310.) Prerequisite or corequisite: BCBP-4760 and BIOL-4620, or permission of instructor. Fall term, odd-numbered years.  
4 credit hours  

BCBP-4710 Biochemistry Laboratory  
Major principles of biochemistry are illustrated as students purify and analyze specific proteins. Experience is obtained with various techniques including tissue extraction, chromatography, ultracentrifugation, spectrophotometric analysis, and electrophoresis. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports. (Students cannot obtain credit for both this course and BIOL-4710.) Prerequisite: BIOL-2120. Spring term annually.  
4 credit hours  

BCBP-4760 Molecular Biochemistry I  
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics covered include protein and nucleic acid structure, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4760 or CHEM-4760.) Prerequisites: CHEM-2250 or CHEM-2210 and BIOL-2120 or equivalent. Fall term annually.  
4 credit hours  

BCBP-4770 Molecular Biochemistry II  
The second semester of the molecular biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4770 or CHEM-4770.) Prerequisite: BCBP-4760 or equivalent. Spring term annually.  
4 credit hours  

BCBP-4780 Protein Folding  
The biophysical mechanism of protein folding and the role of misfolding in human diseases is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer’s and other amyloid diseases, cystic fibrosis, and Prion-related syndromes. Spring term even-numbered years. Prerequisite: BCBP-4760 or equivalent. (Students may not receive credit for both this course and BCBP-6780, CHEM-4780, or CHEM-6780.)  
4 credit hours  

BCBP-4790 Protein Chemistry  
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein chimera using semisynthesis. (Students cannot receive credit for this course and BCBP-6790 or CHEM-4790.) Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Recommended for seniors; juniors should talk to the instructor before registering. Spring term, odd-numbered years.  
4 credit hours
BCBP-4810 Biological Spectroscopy
Explores the use of spectroscopic methods to study biological systems. Theory and application of techniques including UV-visible absorbance spectroscopy, IR spectroscopy, fluorescence, electron paramagnetic resonance and nuclear magnetic resonance, and their application to the study of the structure of macromolecules, enzyme mechanism, and other important biological problems covered. (Students cannot obtain credit for both this course and BCBP-6810.) Prerequisite: BCBP-4760 or equivalent. Fall term even-numbered years. 4 credit hours

BCBP-4860 Protein and Nucleic Acid Structure
The three-dimensional structure of these biological macromolecules is explored in detail, with special attention to the relationship of structure and function. Other topics include methods used to determine structure, the thermodynamics of structure formation, structure prediction from primary sequence, and computer-based molecular modeling. (Students cannot obtain credit for both this course and BCBP-6860.) Prerequisite: BCBP-4760 or equivalent. Spring term even-numbered years. 4 credit hours

BCBP-4870 Crystallographic Analysis of Protein Structure
X-ray crystallography is the method of choice for determining the three-dimensional structure of biological macromolecules. We will cover the crystallographic method, its theory and practice, followed by a detailed exploration of selected protein structures. Other topics include the thermodynamics of structure formation, structure prediction from primary sequence, and molecular dynamics. (Students cannot obtain credit for both this course and BCBP-6870.) Prerequisite: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term odd-numbered years. 4 credit hours

BCBP-6210 Biophysical Methods
Topics covered will include electron microscopy of ordered samples, structural databases, hydrodynamics of biological macromolecules, viscosity, sedimentation, translational and rotational diffusion, chromatography, conductance, dielectrophoresis, dynamic light scattering, flow and electric birefringence, and electrophoresis. Also water as a solvent, polyelectrolytes, and Debye-Huckel theory. (Students cannot obtain credit for both this course and BCBP-4210.) Prerequisite: CSCI-1100, BIOL-2120, CHEM-2440, and PHYS-1100 or equivalents. Spring term odd-numbered years. 4 credit hours

BCBP-6310 Genetic Engineering
Case studies on the effect of genetic engineering on medicine, agriculture, biology, forensics, and various other areas of technology. Each week a set of assigned readings will be discussed. Some of the topics to be covered are vaccines, biomolecular computing and electronics, paleontology, ecology, bioremediation, and polymers. (Students cannot obtain credit for both this course and BCBP-4310.) Prerequisite or corequisite: BCBP-4760 and BIOL-4620, or permission of instructor. Full term, odd-numbered years. 4 credit hours

BCBP-6780 Protein Folding
The biophysical mechanism of protein folding and the role of misfolding in human diseases is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer’s and other amyloid diseases, cystic fibrosis, and Prion-related syndromes. (Students may not receive credit for both this course and BCBP-4780, CHEM-4780, or CHEM-6780.) Prerequisite: BCBP-4760 or equivalent. Spring term even-numbered years. 4 credit hours

BCBP-6790 Protein Chemistry
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein ‘chimeras’ using semisynthesis. (Students can not receive credit for this course and BCBP-4790 or CHEM-4790.) Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Spring term, odd numbered years. 3 credit hours

BCBP-6810 Biological Spectroscopy
Explores the use of spectroscopic methods to study biological systems. Theory and application of techniques including UV-visible absorbance spectroscopy, IR spectroscopy, fluorescence, electron paramagnetic resonance and nuclear magnetic resonance, and their application to the study of the structure of macromolecules, enzyme mechanism, and other important biological problems covered. (Students cannot obtain credit for both this course and BCBP-4810.) Prerequisite: BCBP-4760 or equivalent. Fall term even-numbered years. 4 credit hours

BCBP-6860 Protein and Nucleic Acid Structure
The three-dimensional structure of these biological macromolecules is explored in detail, with special attention to the relationship of structure and function. Other topics include methods used to determine structure, the thermodynamics of structure formation, structure prediction
from primary sequence, and computer-based molecular modeling. (Students cannot obtain credit for both this course and BCBP-4860.) Prerequisite: BCBP-4760 or equivalent. Spring term even-numbered years.

**BCBP-6870 Crystallographic Analysis of Protein Structure**

X-ray crystallography is the method of choice for determining the three-dimensional structure of biological macromolecules. We will cover the crystallographic method, its theory and practice, followed by a detailed exploration of selected protein structures. Other topics include the thermodynamics of structure formation, structure prediction from primary sequence, and molecular dynamics. (Students cannot obtain credit for both this course and BCBP-4870.) Prerequisite: BCBP-4760, MATH-1020, and PHYS-1200 or equivalents. Fall term odd-numbered years.

**BCBP-6940 Readings in Biochemistry/Biophysics**

Independent study of selected readings in the fields of biochemistry and biophysics, supervised by a faculty member. Prerequisite: permission of instructor. Offered each term.

1 to 4 credit hours

**BCBP-6970 Professional Project**

Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

**BCBP-6990 Master's Thesis**

Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

**BCBP-9990 Dissertation**

Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

---

**BIOL Biology (SOS)**

**BIOL-1010 Introduction to Biology**

Introduction to animals, microorganisms, and plants. Discussion of problems associated with biological organization. The ecology of individuals and populations. Introduction to biochemical, evolutionary, genetic, physiological, and developmental principles. The course considers the biological components of various societal and individual problems. Laboratory teaches how science is done by students making observations and then developing and experimentally testing student formulated hypotheses. (Students cannot receive credit for both this course and BIOL-1040.) Fall term annually. 4 credit hours

**BIOL-1020 Introduction to Biology Laboratory**

Laboratory teaches how science is done by students making observations and then developing and experimentally testing student formulated hypotheses. Fall term annually.

1 credit hour, 3 contact hours

**BIOL-1040 Biology for Non-Majors**

Introduction to animals, microorganisms, and plants. Discussion of problems associated with biological organization. The ecology of individuals and populations. Introduction to biochemical, evolutionary, genetic, physiological, and developmental principles. The course considers the biological components of various societal and individual problems. This course meets with BIOL-1010 for lectures but in place of the laboratory, students will consider special topics in an additional class period. (Students cannot receive credit for both this course and BIOL-1010.) Fall term annually. 4 credit hours

**BIOL-2120 Introduction to Cell and Molecular Biology**

Structural and functional relationships of cells are discussed with regard to similarities among all living organisms. Introduction to cellular biochemistry, metabolism and energy flow, cellular and Mendelian genetics, and the chemical basis of heredity. The laboratory exercises illustrate current concepts in cellular and molecular biology. Spring term annually. 4 credit hours, 6 contact hours

**BIOL-2160 Introductory Biotechnology**

The application of biological principles and materials in the production of commercially important products. Fermentation, biocatalysis, hybridoma technology, and plant cell culture are treated in the history and development of modern biotechnology, including social aspects. Prerequisite: BIOL-1010 or BIOL-2120. Spring term even-numbered years. 3 credit hours

**BIOL-2310 Microbiology**

The morphology and the physical and chemical activities of bacteria, yeasts, molds, and viruses. Laboratory work in techniques of microbiology. Quantitative aspects. Spring term annually. 4 credit hours, 6 contact hours
BIOL-2410 Embryology
Anatomical, cellular, and molecular aspects of germ cell formation, fertilization, early development, morphogenesis, induction, and differentiation. Extra-embryonic adaptation and hormonal controls are also discussed, concluding with a summary of current concepts on eucaryotic gene expression and regulation. Prerequisite: BIOL-2120. Summer term annually; spring term odd-numbered years. 4 credit hours, 6 contact hours

BIOL-2500 Genetics and Evolution
Mechanisms of inheritance in eukaryotes and prokaryotes; genetic mapping, gene expression, cloning and sequencing; quantitative and population genetics, and synthetic theory of evolution. Prerequisite: BIOL-2120. Fall, spring, summer session 2 annually. 4 credit hours

BIOL-2900 Research in Biology
Independent study program for the purpose of developing research skills under the guidance of a faculty member. This course may be repeated and it cannot count as a biology elective. Prerequisite: permission of instructor. Fall, spring, and summer terms annually. 1 to 4 credit hours, 3 to 12 contact hours

BIOL-2930 Out-of-Classroom Experience in Biology
Credit to be given for an out-of-classroom experience related to biology having intellectual content relevant to the student’s educational or career goals, subject to approval of a written proposal and a final report. The adviser (for biology majors) or, with permission, any Biology faculty member may serve as evaluator. For each out-of-classroom experience, a student may register only once for one to four credit hours. This course cannot be used as a Biology Elective. Fall, spring, and summer terms annually. 1 to 4 credit hours

BIOL-2980 Biomedical Research
Independent research in health sciences, supervised by a faculty member, for the purpose of developing research skills. Open to students in the accelerated biomedical or biodental curriculums only. Prerequisite: permission of instructor. Summer term annually. 6 credit hours

BIOL-2990 Research
Thesis independent research, supervised by a faculty member, culminating in a written thesis. Cannot be used as a Biology Elective. Prerequisite: permission of instructor. Fall, spring, and summer terms annually. 4 credit hours (maximum of 8), 12 contact hours

BIOL-4260 Cell Biology
Biochemical and morphological evidence underlying current models of cell structure and function. Topics covered include roles of membranes in cell compartmentation, organelle structure and biogenesis, vesicle transport, secretion, cytoskeleton, motility, signaling, mitosis, and cell cycle regulation. Distinctive characteristics of differentiated mammalian cells are examined. The format includes faculty lectures, computer-based tutorials, and student presentations. Prerequisite: BIOL-4760 or permission of instructor. Spring term annually. 4 credit hours

BIOL-4270 Human Physiology I
Introduction to fundamental physiological processes and their mechanism of action in human organismal systems. Membrane structure and function, transport mechanisms, action potentials, and synaptic transmission. Skeletal, cardiac, and smooth muscle structure, function, and control. Sensory receptors and neural coding. The nervous system. Fall term annually. 4 credit hours

BIOL-4280 Human Physiology II
Study of basic physiological principles in human and higher mammalian organisms. Emphasis on interaction and control of physiological systems, their control and interaction. Introduction to circulatory, renal, respiratory, digestive, reproductive, and hormonal systems. Prerequisite: BIOL-4270. Spring term annually. 4 credit hours

BIOL-4290 Human Physiological Systems
Study of basic physiological principles in human and higher mammalian organisms. Emphasis on interaction and control of physiological systems. Introduction to neural, motor, sensory, circulatory, renal, respiratory, reproductive, and hormonal systems. Non-Majors only. No prerequisite. Fall term annually. 4 credit hours

BIOL-4310 Industrial Microbiology
A survey of the uses of microorganisms in production of commercially important products, decomposition of wastes, and control of nuisance microorganisms. Development of fermentation processes, types of fermentation equipment, product recovery, and fermentation economics are discussed. Prerequisites: BIOL-2310 and BIOL-4760 or CHEM-2250, or permission of instructor. Spring term odd-numbered years. 3 credit hours

BIOL-4320 Geomicrobiology
Microbial activities on rock and minerals; in soils and sediments. Microbial relationships to fossil fuels. Pertinent topics in limnology and marine microbiology. Prerequisite: BIOL-2310 or BIOL-6310 or ERTH-1010, or permission of instructor. Spring term annually. 3 credit hours

BIOL-4360 Introductory Virology
Natural history of virus diseases. In vitro virus-cell interactions. Physical and chemical properties of viruses and their nucleic acids. Prerequisite or corequisite: BIOL-2310 or BIOL-2500. Fall term annually. 4 credit hours

BIOL-4370 Introduction to Microbial Physiology
Unique aspects of the physiology of bacteria and blue-
green algae are considered. Fine structure and function, metabolism and reproduction are integrated into a common framework at the molecular and cellular level. Specific topics include microbial transport, heterotrophy, fermentation, autotrophy, nitrogen, sulfur and carbon metabolism, microbial growth and morphogenesis in the prokaryotes. Prerequisites: BIOL-2310 and BIOL-4760. Spring term odd years. 3 credit hours

BIOL-4380 Introduction to Microbial Genetics
An introduction to mechanisms of gene transfer in bacteria. Mutant selection and genetic manipulations using classical and recombinant DNA techniques will be discussed. Life cycles of bacteriophage are studied. Discussion of original journal articles will be used to supplement other course material. Prerequisites: BIOL-2120, BIOL-2500. Fall term even-numbered years. 4 credit hours

BIOL-4390 Introductory Medical Microbiology
A discussion of pathogenic bacteria. Major topics are the biology, mechanisms of pathogenicity, laboratory identification of these organisms, and the various mechanisms of host defense. Organisms pathogenic for man are stressed. Fall term odd-numbered years. 4 credit hours

BIOL-4410 Plagues, Politics, and People
The origin of plagues old and new are the main theme of this course. Through such sources as the Bible and Shakespeare we also see how previous societies have responded to epidemics in ways that are very similar to what we are experiencing now with AIDS, a disease that has and will impact the civilized world like none other in history. An overview of the basic principles of microbiology are woven into the story. Spring term annually. 1 credit hour

BIOL-4420 Introductory Immunology
An introduction to immune responses, antigen-antibody reactions, antibody structure and formation, blood groups, and antibody-mediated and cell-mediated hypersensitivity. Prerequisites: BIOL-2120 and BIOL-2310. Fall term annually. 4 credit hours

BIOL-4430 AIDS: Paradise Lost
AIDS, with its combination of sex, death, and celebrities, holds a strong fascination for our society. The AIDS story is a complex one, shaped by a number of forces. While the primary focus is on the biology of the HIV virus and its interface with the immune system, we do not neglect how social, technical, administrative, political, legal, and economic factors mold the AIDS story. Student presentations of current topics in the AIDS epidemic will be an integral part of the course. (Cross listed as PSYC-4630. Students cannot obtain credit for both this course and PSYC-4630.) Prerequisite: BIOL-2120. Spring term annually. 4 credit hours

BIOL-4440 Microbial Ecology
A study of the interactions between microbes and their environments. Discussion includes the physiological ecology of microorganisms (effects of physical parameters on microbial distribution and activities in nature), dispersal mechanisms in nature, associations with higher organisms, and the role of man in manipulating microbial activities. Prerequisite: BIOL-2310 or permission of instructor. Fall term annually. 3 credit hours

BIOL-4510 Molecular Genetics
Mechanisms of gene action and inheritance at the molecular level. Submicroscopic structure of the cell. Relationships between cell structure and function. Mechanisms of protein and nucleic acid synthesis. Prerequisite: BIOL-2500. Fall term annually. 3 credit hours

BIOL-4540 Bioinformatics I
The course covers concepts and methods related to information processing in biological systems. Concepts covered include homology, identity and similarity; mechanisms and measures of molecular evolution; introduction to data bases (e.g., GenBank, PDB); search algorithms (BLAST); pairwise sequence alignment using dynamic programming (GAP, BestFit); progressive methods for multiple alignment (CLUSTAL, PILEUP). Selected topics include molecular biology applications (shotgun sequencing analysis, PCR primer design). Prerequisites: MATH-1020, BIOL-4620, BIOL-4760. Fall term annually. 4 credit hours

BIOL-4550 Bioinformatics II
The course covers use of homology to extract information about structure and function from amino acid sequences. Concepts covered include structural homology, structural motifs and data bases, homology modeling of macromolecules, energy minimization and relaxation, molecular docking, and introduction to molecular dynamics. Prerequisite: BIOL-4540 (Bioinformatics I). Spring term annually. 4 credit hours

BIOL-4620 Molecular Biology
Nucleotide biosynthesis; structure, replication, transcription, and translation of nucleic acids; reassociation of nucleic acids; molecular cloning, sequencing, and endonuclease mapping of DNA; control of gene expression in bacteria and higher organisms. Prerequisite: BIOL-2120 and BIOL-2500 (or concurrent). Spring term annually. 4 credit hours

BIOL-4630 Molecular Biology II
This course will provide students with an in-depth examination of the molecular mechanisms involved with gene regulation. The goal of this course will be to expose students to the complexity of regulation of specific biological phenomena, emphasizing current areas of research interest. Examples of semester topics include aspects of immunity, the cell cycle and oncogenes, phage replication and
infection, and cellular growth and development. Prerequisites: BIOL-4720, BIOL-4760. Fall term annually.

BIOL-4700 Freshwater Ecology
Quantitative examination of major biological fresh water communities. Delineation of the physical and chemical regimes under which aquatic organisms exist. Basic limnological processes are studied to define aquatic systems of differing physical characteristics. Nutrient chemistry analyses of waters of varying acidity, alkalinity, and chemical loadings are related to their trophic status. Microcosm stimulation experiments delineate nutrient and food chain perturbations. Laboratory is taught at the Darrin Fresh Water Institute at Lake George and various field locations in the Adirondacks for two weeks during August. Prerequisite: BIOL-1010 or equivalent or permission of instructor. Summer term annually.

BIOL-4710 Biochemistry Laboratory
Major principles of biochemistry are illustrated, as students purify and analyze specific proteins. Experience is obtained with various techniques including tissue extraction, chromatography, ultracentrifugation, spectrophotometric analysis, and electrophoresis. The course includes extensive hands-on laboratory work, as well as the writing of in-depth reports, and is qualified as a writing-intensive course. (Students cannot obtain credit for both this course and BCBP-4710.) Prerequisite: BIOL-2120. Spring term annually.

BIOL-4720 Molecular Biology Laboratory
The techniques of gel electrophoresis, restriction enzyme mapping, and molecular hybridization are applied to the study of bacterial plasmids and mammalian genes. This is a writing-intensive course. Prerequisite: BIOL-2120. Fall term annually.

BIOL-4740 Cell and Developmental Biology Laboratory
This course examines the biological roles of the extracellular matrix and cytoskeletal proteins in human normal and cancer cells. Experimental techniques include cell culture, immunofluorescence microscopy, computer image analysis, and various biochemical methods. This is a writing-intensive course. Prerequisite: BIOL-2120. Fall term annually.

BIOL-4760 Molecular Biochemistry I
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics covered include protein and nucleic acid synthesis, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BCBP-4760 or CHEM-4760.) Prerequisites: CHEM-2250 or CHEM-2210 and BIOL-2120 or equivalent. Fall term annually.

BIOL-4770 Molecular Biochemistry II
The second semester of the molecular biochemistry sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BCBP-4770 or CHEM-4770.) Prerequisite: BIOL-4760 or permission of instructor. Spring term annually.

BIOL-4850 Principles of Ecology
A study of the fundamental principles of the ecology of plants and animals. Interrelationships between organisms and their environments are discussed as well as material and energy balances in the ecosystem. Emphasis on the biology of populations (producers, consumers, and decomposers). Prerequisite: BIOL-2120 or BIOL-1010. Fall term annually.

BIOL-4870 Environmental Toxicology
A study of the origins, transport, fate, and effects of toxic chemicals in the environment. Includes discussion of selective toxicity, biochemical modification, and tissue interactions for several classes of toxic chemicals. Prerequisites: BIOL-1010 and BIOL-2120. Spring term even-numbered years.

BIOL-4940 Readings in Biology
Selected readings in the biological literature to supplement the scientific background of undergraduate students. Cannot be used as a Biology Elective. Prerequisite: permission of instructor. Fall, spring, and summer terms annually.

BIOL-6310 Microbiology
An intensive review of the basic concepts of cellular organization, intermediary metabolism, and respiration in microorganisms. Particular emphasis is placed on the relationship between microorganisms and man. Spring term annually.

BIOL-6330 Bacterial Physiology
Discussion of the physiology of microorganisms. Emphasis placed upon bacteria with pertinent aspects of yeasts, molds, and viruses. Topics cover cell anatomy, growth and reproduction, general metabolism, and microbial enzyme systems. Prerequisite: BIOL-2310. Spring term odd-numbered years.

BIOL-6360 Microbial Genetics
A survey of the current status of microbial genetics (bacteria, viruses, and fungi), including discussions of methods.
BIOL-6690 Applied and Environmental Microbiology
A survey of applied aspects of microbiology including the application of microorganisms in industrial processes and the roles played by microorganisms in the environment. Emphasis is placed on ways in which microorganisms can be manipulated and controlled for human advantage. Current literature regarding manipulation and regulation of microbial activities is discussed. Prerequisite: BIOL-4390, with extra readings, etc. Fall term odd-numbered years. 3 credit hours

BIOL-6720 Molecular Biology of Plants
The course will cover several topics that are currently at the forefront of study of the molecular biology of flowering plants. These include: 1) the organization of DNA sequences in nuclear chromosomes and in those of mitochondria and chloroplasts; 2) the regulation of transcription and translation of tissue-specific and environmentally sensitive genes; 3) gene expression in the development and functioning of chloroplasts and mitochondria; 4) methods of transformation of plants and the use of transgenic plants to answer questions of basic plant molecular biology and development; and 5) the engineering of new traits in plants. The course assumes a familiarity with basic biochemistry and molecular biology. Taught jointly with the State University of New York at Albany. Fall term even-numbered years. 3 credit hours

BIOL-6900 Seminar in Biology
Weekly discussion of selected topics in biology by graduate students and staff. Fall and spring terms annually. 3 credit hours

BIOL-6940 Readings in Biology
Readings in the current literature designed to supplement the background of the student and provide greater depth in the area of his or her specialty. Prerequisite: permission of instructor. Fall, spring, and summer terms annually. 1 to 4 credit hours

BIOL-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project, but, with departmental or school supervision of a faculty adviser, it can be used to fulfill other program requirements. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project, but, with departmental or school supervision of a faculty adviser, it can be used to fulfill other program requirements. 1-9 credit hours

BIOL-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades of A,B,C, or F are assigned but are not submitted to the Graduate School and are not archival in the library. Grades of A,B,C, or F are assigned but are not submitted to the Graduate School and are not archival in the library. A master's thesis is often used to fulfill other program requirements. With approval, students may register for more than one Professional Project, but, with departmental or school supervision of a faculty adviser, it can be used to fulfill other program requirements. A master's thesis is often used to fulfill other program requirements. 1-9 credit hours
defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

BMED Biomedical Engineering (SOE)

BMED-2200 Dynamic Systems for Biomedical Engineering
Introduction to the modeling, analysis, and control of dynamic systems. Models of electrical, mechanical, electromechanical, and mass-transport systems in state-variable, input-output, and transfer function form. Linear approximations of nonlinear systems. Time domain and Laplace transform solutions, Block diagrams, and feedback systems. Solutions using a standard software package with graphic user interface. Corequisites: MATH-2400, PHYS-1200. Spring term annually. 4 credit hours

BMED-2940 Studies in Biomedical Engineering
Each term. 1 to 4 credit hours

BMED-2960 Topics in Biomedical Engineering
Each term. 1 to 4 credit hours

BMED-4010 Biomedical Engineering Laboratory
Theory and practice of biomedical measurements. An introduction to instruments and procedures for measurement of pressure, flow, bioelectrical potentials, biomechanical and biomaterial properties, using invasive and noninvasive techniques. Transducers studied include strain gauge, differential transformer, spectrometer, blood gas electrodes, bipotential electrodes, microscope with camera, mechanical testing machine, piezoelectric transducer (or sensor). Also studied are instruments for determination of material properties. Prerequisites: BMED-2200, BMED-4500 or permission of instructor. Fall term annually. 4 credit hours

BMED-4240 Tissue-Biomaterial Interactions
Relationships between structure and properties of synthetic implant materials, including metals, polymers, ceramics, and composites. The emphasis is on mechanical, corrosion, and surface properties of materials. An introduction to biocompatibility with special emphasis on the interaction of biomaterials with cells and tissues. Detailed review of blood-material interactions. Case studies of implants are discussed to illustrate biomaterials selection as a key part of implant design. Prerequisites: ENGR-1600, BIOL-4290, or permission of instructor. Spring term annually. 4 credit hours

BMED-4470 Signals and Images
Principles of computer-based signal processing and imaging, covering the theoretical basis and practical applications. Topics include acquiring biomedical images, image correction and enhancement, signal and image processing, and 3-D images. Applications are to tomographic imaging, ultrasound, and microscopy. Prerequisite: BMED-2200. Spring semester, even-numbered years. 4 credit hours

BMED-4490 Sensors and Instruments
The engineering science that gives rise to the successful performance of medical instruments when they are connected to living systems. The physical and chemical laws that are applied to sensing, actuating, and control functions in medical devices. Models and designs are discussed in terms of optimum use of fundamental relationships, accommodating fundamental constraints, and meeting medical requirements. Consideration is given to identifying the role of instrument design in the diagnosis of diseases and the therapy to treat those diseases. Prerequisite: ECSE-2410. Spring term, odd-numbered years. 4 credit hours

BMED-4500 Advanced Systems Physiology
Applications of control theory and systems techniques to physiology. Emphasis is on entire systems and their interactions rather than isolated phenomena. Areas covered include cardiac, respiratory, renal, and gastrointestinal systems. Includes laboratory on the application of engineering techniques in the study of physiological systems. Prerequisite: BIOL-4290 or equivalent. Spring term annually. 4 credit hours

BMED-4540 Biomechanics
Application of mechanics to the study of normal, diseased, and traumatized musculo-skeletal system. Areas covered include determination of joint and muscle forces, mechanical properties of biological tissues, and structural analysis of bone-implant systems. Case studies are discussed to illustrate the role of biomechanics and biomaterials in the design of implants. Prerequisite: ENGR-2050, corequisite: BMED-2200. Fall term annually. 4 credit hours

BMED-4600 Biomedical Engineering Design
A guided approach to development of design skills. Students work individually and in teams to tackle a biomedical design problem using methods drawn as necessary from engineering and from the physical and mathematical sciences. Discussion sessions involve students in presentations of work. This is a writing-intensive course. Prerequisite: senior standing. Spring term annually. 3 credit hours

BMED-4650 Introduction to Cell and Tissue Engineering
This course teaches the use of engineering principles to describe cellular processes of biological, chemical, and physical nature. A quantitative approach will be used to explain the behavior of cells under various physical stimuli through the application of the laws of physics, mathematics, and physical biochemistry. The transduction of
these physical stimuli into modified behavior and their impact on organ level performance/function and tissue engineering will be discussed in the case of mammalian cells. Prerequisite: A basic course in mechanics (ENGR-2530 or BMED-4540, and a basic course in transport phenomena or fluid dynamics (ENGR-2250 or equivalent), or permission of instructor. Fall semester annually. 3 credit hours

**BMED-4940 Studies in Biomedical Engineering**
Each term. 1 to 4 credit hours

**BMED-4960 Topics in Biomedical Engineering**
Each term. 1 to 4 credit hours

**BMED-6240 Tissue-Implant Interfaces**
An examination of biomaterial and biomechanical factors affecting events at tissue-implant interfaces, with emphasis on biomaterial surface properties as well as cell and molecular interactions. Prerequisites: BIOL-4290 and BMED-4500 or permission of instructor. Fall term annually. 3 credit hours

**BMED-6280 Biomechanics of Soft Tissues**
Application of continuum mechanics in modeling the biomechanical behavior of nonmineralized tissues such as tendons, ligaments, skin, cartilage, blood vessels, etc. Topics include structure of collagen, elastin, proteoglycans, and other tissue components, nonlinear elastic models (including Fung’s pseudoelasticity approach and strain energy functions), linear viscoelasticity, Fung’s quasilinear viscoelasticity, hereditary integral formulation of constitutive equations, and introduction to mixture theory. Fall term odd-numbered years. 3 credit hours

**BMED-6290 Biomechanics of Hard Tissues**
Structure-property relationships for mineralized connective tissues of the human body. Discussion centers on various types of bone (e.g., lamellar, woven) with an emphasis on models for biomechanical behavior. Topics include elastic models for bone (isotropic and anisotropic), theories of yielding and fatigue, strength properties, composite and hierarchical models, and models of bone remodeling/modeling. Fall term even-numbered years. 3 credit hours

**BMED-6350 Fluid Dynamics and Transport in the Vascular Circulation**
The principles of convective diffusion in liquids are discussed as applied to the vascular circulation. Topics include: convective and diffusion boundary layers in internal flows with reacting and/or permeable walls, Taylor dispersion, microhydrodynamics of macromolecules and particles, Brownian motion, mass transport to arterial walls and across cell membranes. This course is intended for first year graduate students in Biomedical Engineering and undergraduate seniors with permission of the instructor. Spring term, even-numbered years. 3 credit hours

**BMED-6480 Adaptive Systems**
This course contains the fundamental theory required to design adaptive systems. Topics include parameter identification, ARMA modeling, model reference systems, model algorithmic control, self-tuning systems, and adaptive filtering. Applications to physical and physiological systems are introduced. (Cross listed as ECSE-6480). Prerequisite: ECSE-6400 or equivalent. Spring term odd-numbered years. 3 credit hours

**BMED-6500 Mechanobiology**
Mechanical regulation of biological systems will be discussed. Topics include principles and concepts of mechanobiology; embryogenesis and histogenesis of tissues with particular references to skeletal system; physical forces at cellular, tissue and organ level; mechanical regulation of cellular behavior, tissue growth, and organ development; limits of mechanical regulation; biochemical influences; application of mechanobiology to tissue regeneration. Prerequisites: BMED-4540 or ENGR-2530 with permission from the instructor. Graduate Course; spring semester. 3 credit hours

**BMED-6550 Cell Biomechanics**
The mechanics of single cells and cells in a continuum are discussed in the context of the modulation of cell function by mechanical stresses. Topics include: mechanical forces in the natural environment of various mammalian cells (erythrocytes, leukocytes, osteoblasts, and epithelial cells), mathematical formulations of force distribution and force transmission, cell motility, models of cell membrane skeleton, cell deformability and elasticity, mechanical properties of cell membranes, and role of mechanical forces in cell structure/function. Prerequisites: BMED-4540 or ENGR-2530 with permission from the instructor. Spring alternate years. 3 credit hours

**BMED-6690 Topics in Biomedical Engineering**
Each term. 1 to 4 credit hours

**BMED-6940 Studies in Biomedical Engineering**
Offered by individual arrangement. 3 credit hours

**BMED-6960 Topics in Biomedical Engineering**
New courses or special course offerings are given under this number from time to time. Graduate students in biomedical engineering may pursue special interests under this number when sponsored by a biomedical engineering faculty member and with the permission of the department. Offered by individual arrangement. 1 to 4 credit hours

**BMED-6980 Master’s Project**
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the Master’s Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours
BMED-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

BMED-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

BMED-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended. The dissertation must be approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

CHEM Chemistry (SOS)
CHEM-1100, CHEM-1200 Chemistry I, II
Laws and theories of modern chemistry. Relationship between structure and properties of materials. The dynamics of chemical changes are studied with an emphasis on equilibrium, thermodynamics, and kinetics. Laboratory work includes preparative and analytical experiments. Prerequisite: CHEM-2210. Recommended for chemistry and chemical engineering majors. Students cannot receive credit for both CHEM-1100 and CHEM-1100. Spring term annually. 4 credit hours

CHEM-1300 Chemical Principles for Engineers
An introduction to the basic principles of chemistry with an emphasis on applications in everyday scientific and engineering practice. Topics covered include atomic and molecular structure, particle and wave behavior of light and matter, periodic properties of elements, oxidation-reduction, stoichiometry, molecular bonding, introduction to organic and biochemistry, thermodynamics, phases of matter including gas laws, intermolecular forces, chemical equilibrium, simple one and two component phase diagrams, acids-bases-buffers, and chemical kinetics. Laboratory is integrated into the course. Students cannot obtain credit for both this course and CHEM-1100. Fall term. 4 credit hours

CHEM-2030 Inorganic Chemistry I
Descriptive chemistry of the elements. Properties, structures, and typical reactions of the elements of the periodic table and their compounds; basic principles of inorganic chemistry. Prerequisite: CHEM-1200 or ENGR-1600 (Mat'l Sci. for Eng.). Spring term annually. 4 credit hours

CHEM-2150 Equilibrium Chemistry and Quantitative Analysis
Principles of equilibrium chemistry (particularly solubility and acid/base chemistry) and its application to chemical analysis will be the principal focus of the lecture and laboratory. Applications of equilibrium chemistry in the fields of geology, environmental science, biology, and biochemistry will be included in the lecture portion of the course. The laboratory will cover both wet and instrumental techniques of chemical analysis. Prerequisite: CHEM-1200 or CHEM-1300. Fall term annually. 4 credit hours

CHEM-2210 Organic Compounds and Reactions
Structural aspects of organic chemistry and the relation between structure and reactivity of organic compounds. Extensive use is made of information derived from infrared, ultraviolet, and nuclear magnetic resonance spectroscopy. Recommended for chemistry and chemical engineering majors. Students cannot receive credit for both CHEM-2250 and CHEM-2210. Prerequisite: CHEM-1200 or CHEM-1300 or ENGR-1600 or equivalent. Fall term annually. 4 credit hours

CHEM-2220 Organic Synthesis
A laboratory-lecture course, which is a continuation of CHEM-2210 with a focus on synthetic methods in organic chemistry. The laboratory emphasizes synthetic organic chemistry techniques. Prerequisite: CHEM-2210. Spring term annually. 4 credit hours

CHEM-2230, CHEM-2240 Organic Chemistry Laboratory I, II
The laboratory work associated with CHEM-2250 and CHEM-2260; for students who have already taken theory courses in organic chemistry. A fall-spring sequence annually. 1 credit hour, 3 contact hours each

CHEM-2250 Organic Chemistry I
Structure, chemical behavior, occurrence and uses of organic compounds. Compounds of biological, environmental, and industrial importance are specifically addressed. The laboratory provides experience in synthesis and characterization of organic compounds. Recommended for students in biology and health related areas. Students cannot obtain credit for both CHEM-2250 and CHEM-2210. Prerequisite: CHEM-1200 or CHEM-1300 or equivalent. Fall term annually. 4 credit hours
CHEM-2260 Organic Chemistry II
A continuation of CHEM-2250, which is a prerequisite. Students cannot obtain credit for both CHEM-2260 and CHEM-2220. Spring term annually. 4 credit hours

CHEM-2270 Introduction to Organic Chemistry
The theory part of CHEM-2250 for students in Environmental Engineering or others who require only a 3-credit introductory course without laboratory in Organic Chemistry. Students may not receive credit for both CHEM-2250 and this course. Prerequisite: CHEM-1300. Fall term annually. 3 credit hours

CHEM-2360 Chemistry Laboratory: Selected Experiments
A selection of experiments taken primarily from other chemistry laboratory courses. Intended to permit an individualized laboratory course to be set up to enable transfer students to make up deficiencies in their laboratory background, to allow students from other departments to obtain experience in areas of interest to them, and to provide a course that students from other schools can use to fulfill laboratory requirements of their home institution on a transfer basis. Selection of experiments and credits determined by individual consultation with the academic adviser and instructor. Fall and spring terms annually.

CHEM-2440 Physical Chemistry for Life Sciences
Topics in physical chemistry that are important for understanding processes in biological systems. Included are: thermodynamics as applied to phase and chemical equilibria in chemical and biochemical systems; passive transport models for diffusion and electrical conductivity in electrolyte solutions; kinetic models for simple and complex chemical reactions, including enzyme mechanisms; quantum mechanical models used in spectroscopy. Prerequisites: CHEM-1200 and MATH-1010. Fall term annually.

CHEM-2540 Introduction to Geochemistry
A lecture-laboratory course dealing with more advanced topics of inorganic chemistry, including molecular symmetry, application of symmetry concepts to molecular orbital descriptions of polyatomic molecules, solid state and nonstoichiometric compounds, coordination chemistry, spectral and magnetic properties, and organometallic chemistry. The laboratory explores the characteristics of several types of inorganic compounds, with emphasis on the use of physical methods in inorganic chemistry. This is a writing-intensive course. Prerequisite: CHEM-2030; it is recommended that CHEM-4450 be taken concurrently. Fall term annually. 4 credit hours

CHEM-2950 Undergraduate Research
Hands-on research in a faculty research laboratory. Prerequisite: permission of instructor. Offered each term. 1 to 4 credit hours

CHEM-2940 Special Projects in Chemistry
Study and experimental work in various fields of chemistry to develop an interest in and ability for independent study and investigation. Prerequisite: permission of instructor. Fall and spring terms annually. 1 to 4 credit hours

CHEM-3900 Environmental Measurements
Modern methods used in analysis of environmental samples for monitoring and research purposes. Standard and advanced techniques of air, water, sediment, and soil analysis are covered including spectrometric and chromatographic methods. (Cross listed as ERTH-4190. Students cannot obtain credit for both this course and ERTH-4190.) Prerequisite: permission of the instructor required. Fall term odd-numbered years. 4 credit hours
CHEM-4300 Medicinal Chemistry
Organic and medicinal chemistry play a crucial role in the discovery of agents used to treat human disease. The basis of this course is the study of the drug discovery process from the perspective of these chemical disciplines. Concepts to be studied are molecular targeted drug discovery, lead compound identification and optimization, biophysical and molecular modeling tools, biological barriers to drug action and ways chemistry can overcome them, and the biotech industry. Topics pertinent to drug development such as drug metabolism and clinical research will also be discussed. Prerequisite: CHEM-2220 or CHEM-2260 or permission of instructor. 4 credit hours

CHEM-4310 Bioorganic Mechanisms
The study of mechanisms of organic reactions in biochemical processes on a molecular level. Enzyme active sites, mechanisms of enzymatic transformations, catalysis, cofactors, enzyme kinetics, environmental toxicology. Strong emphasis on the design and mechanism of action of pharmaceutical agents. Meets with CHEM-6310; both courses cannot be taken for credit. Prerequisite: CHEM-2220 or CHEM-2260 or permission of instructor. Fall term. 4 credit hours

CHEM-4330 Drug Discovery
This course will focus on the applications of bioinformatics and genomics to the discovery of organic molecules useful in treating human disease. Starting with a therapeutically relevant molecular target, topics include the pharmacophore, high throughput screening, combinatorial chemistry, chip-based automated synthesis, and combinatorial biology. In the laboratory, students will practice the chemical and biological aspects of screening and develop a pharmacophore model. Prerequisites: CHEM-2220 or CHEM-2260 or permission of instructor. Fall term. 4 credit hours

CHEM-4400 Basic Physical Chemistry
A course intended primarily for students in the Environmental Engineering curriculum that deals with many of the topics of macroscopic physical chemistry. Meets with CHEM-4450 for 3/4 of the semester; both courses cannot be taken for credit. Fall term annually. 4 credit hours

CHEM-4450 Macroscopic Physical Chemistry
A course dealing with physicochemical properties of substances on a macroscopic scale. Chemical thermodynamics, electrochemistry, electric and magnetic phenomena and transport properties. Credit cannot be obtained for both this course and CHEM-4400. Fall term annually. 4 credit hours

CHEM-4460 Microscopic Physical Chemistry
A course dealing primarily with physicochemical properties of substances on a molecular basis. Chemical kinetics, quantum chemistry, spectroscopy, statistical mechanics, surfaces and colloid chemistry. Prerequisite: CHEM-4450 or a thermodynamics background above a 1000-level course. Spring term annually. 4 credit hours

CHEM-4470 Theoretical Chemistry
Introduction to quantum mechanics and applications in chemical systems. Atomic and molecular spectra and structure. Statistical thermodynamics. Prerequisite: CHEM-4450. Fall term annually. 3 credit hours

CHEM-4520 Chemical Information
An introduction to the discipline of chemical information science, including a survey of the printed and electronic sources for chemical information. Prerequisites: CHEM-2210 or CHEM-2250 and CHEM-2030 or permission of instructor. Spring term annually. 1 credit hour

CHEM-4530 Modern Techniques in Chemistry
A lecture/laboratory course for Chemical Engineering students. Discusses the principles and applications of modern instrumental methods of chemical analysis and provides laboratory experience in their use along with other chemical techniques. Principles of analytical, organic, and physical chemistry will be illustrated throughout the course. Prerequisites: Chem-2210. Fall and spring terms annually. 4 credits hours

CHEM-4540 Organic Geochemistry
A broad survey of organic geochemistry suitable for students with a strong chemistry background who are majoring in science or engineering. Topics include the geochemistry of natural organic compounds in oceans, lakes, sediments, and soils and the transport and fate of organic pollutants. (Cross listed as ERTH-4540. Students cannot obtain credit for both this course and ERTH-4540.) Prerequisites: CHEM-2210, ERTH-1200, or permission of instructor. Spring term odd-numbered years. 4 credit hours

CHEM-4620 Introduction to Polymer Chemistry
Measurement of molecular weight and distribution, other characterization methods, organic and kinetic aspects of polymerization, chemical properties and uses of polymers, solution properties. Prerequisites: CHEM-4460. Spring term annually. 4 credit hours

CHEM-4640 Polymer Science Laboratory
Laboratory techniques and experiments in synthesis, characterization, and physical properties of high polymers. Some commercial polymers as well as those synthesized in the laboratory are investigated. Meets with CHEM-6640; both courses cannot be taken for credit. Corequisite: CHEM-4620 or equivalent. Spring term annually. 3 credit hours, 9 contact hours

CHEM-4690 Aqueous Geochemistry
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. The course covers principles of
CHEM-4760 Molecular Biochemistry I
Part I of a two-semester sequence focusing on the chemistry, structure, and function of biological molecules, macromolecules, and systems. Topics include protein and nucleic acid structure, enzymology, mechanisms of catalysis, regulation, lipids and membranes, carbohydrates, bioenergetics, and carbohydrate metabolism. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4760 or BCBP-4760.) Prerequisites: CHEM-2250 or CHEM-2210, and BIOL-2120 or equivalent. Fall term annually. 4 credit hours

CHEM-4770 Molecular Biochemistry II
The second semester of the Molecular Biochemistry I sequence. Topics include lipids and lipid metabolism, amino acid metabolism and the coenzymes involved in this metabolism, nucleic acid synthesis and chemistry, protein synthesis and degradation, integration of metabolism, photobiology, and photosynthesis. This course is taught in studio mode. (Students cannot obtain credit for both this course and either BIOL-4770 or BCBP-4770.) Prerequisite: CHEM-4760 or equivalent. Spring term annually. 4 credit hours

CHEM-4780 Protein Folding
The biophysical mechanism of protein folding and the role of misfolding in human disease is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer's and other amyloid diseases, cystic fibrosis, and Prion-related syndromes. Prerequisite or corequisite: CHEM-4760 or BCBP-4760 or equivalent. Students may not receive credit for this course and BCBP-4780 or BCBP/CHEM-6780. Fall term odd-numbered years. 4 credit hours

CHEM-4790 Protein Chemistry
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of chemistry and physics of protein structure and stability and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein 'chimera' using semisynthesis. Prerequisite: CHEM-4760 or BCBP-4760 or BIOL-4760 or equivalent; CHEM-6190 or BCBP-4810 is an asset. Students cannot receive credit for this course and BCBP-6790 or CHEM-6790. Recommended for seniors; juniors should talk to the instructor before registering. Spring term, odd-numbered years. 4 credit hours

CHEM-4810 Chemistry of the Environment
Chemical processes important in the environment from naturally occurring and man-induced systems. Thermodynamic and chemical considerations of fuels; the thermodynamics of the atmosphere; atmospheric photochemistry; chemistry of natural water systems; chemistry of pesticides, fertilizers, and other important environmental contaminants; aspects of the carbon, nitrogen, and sulfur cycles. (Cross listed as ERTH-4810. Students cannot obtain credit for both this course and ERTH-4810.) Prerequisites: CHEM-1200 and one prior or concurrent course in organic chemistry or permission of instructor. Spring term annually. 4 credit hours

CHEM-4900 Senior Seminar
Weekly seminars on topics of concern to students who are about to embark on their professional careers in Chemistry. Topics will include employment and career opportunities; graduate school; ethical requirements and expectations in the profession; new directions in research and other topical matters. Fall term annually. 0 credit hours

CHEM-4910 Laboratory Glassblowing
Demonstrations and laboratory practice in the construction and repair of glass apparatus used in chemistry. The entire course is graded pass/fail, with no students allowed to take the course on any other basis. In addition, upper-class students may take four other courses pass/fail. Fall term annually. 1 credit hour, 3 contact hours

CHEM-4960 Selected Topics in Chemistry
1 to 4 credit hours

CHEM-4990 Senior Thesis
2 credit hours first term, 3 credit hours second term

CHEM-6020 Advanced Inorganic Chemistry I
Structure and bonding in inorganic molecules and crystals; stabilities of inorganic compounds; coordination chemistry and organometallic compounds; acid-base concepts; nonstoichiometry and phase relationships. Fall term annually. 3 credit hours
CHEM-6030 Advanced Inorganic Chemistry II
Transition metal chemistry, emphasizing structural and bonding interpretations of magnetic and spectral data (ligand field theory); stabilities and reaction mechanisms of complexes; polynuclear complexes, naturally occurring transition metal complexes and their importance in environmental and biological systems. Prerequisite: CHEM-4060. Spring term annually. 3 credit hours

CHEM-6190 Molecular Spectroscopy
Introduction of interaction of light with molecules; theory of molecular energies and applications to rotational, vibrational, and electronic spectroscopy. Prerequisites: CHEM-4450 and CHEM-4460 or permission of instructor. Fall term odd-numbered years. 3 credit hours

CHEM-6210, CHEM-6220 Advanced Organic Chemistry I, II
An introduction to the organic chemical literature. A consideration of reactions of synthetic importance to the organic chemist with emphasis on the influence of structure on the behavior of organic molecules. A fall-spring sequence annually. 3 credit hours each

CHEM-6280 Natural Products Chemistry
A survey of modern synthetic methods used in construction of the major groups of secondary metabolites and related natural products. The essentials of retrosynthetic analysis are presented and instruction in the development of strategies for organic synthesis are offered. Prerequisites: CHEM-6210 and CHEM-6220. Fall term odd-numbered years. 3 credit hours

CHEM-6300 Medicinal Chemistry
The organic chemistry of drug discovery and synthesis will be the focus of this course. Starting with the basic concepts of molecular-targeted drug discovery, the process of lead identification will be explored with special emphasis on drug screening and combinatorial chemistry. The roles of computational chemistry, molecular modeling, and biophysical methods in the understanding of the relationship between structure and biological activity will be studied. The chirality of drugs from both the biological and synthetic perspectives will also be explored. Prerequisite: CHEM-6210 or permission of instructor. 3 credit hours

CHEM-6310 Bioorganic Mechanisms
The study of mechanisms of organic reactions in biochemical processes on a molecular level. Enzyme active sites, mechanisms of enzymatic transformations, catalysis, cofactors, enzyme kinetics, environmental toxicology. Strong emphasis on the design and mechanism of action of pharmaceutical agents. Meets with CHEM-4310; both courses cannot be taken for credit. Prerequisite: permission of instructor. Spring term odd-numbered years. 3 credit hours

CHEM-6450 Nonlinear Laser Spectroscopy
An introduction to the theory and practice of multiphoton or nonlinear laser spectroscopic and nonlinear optical phenomena. Emphasis is placed on the spectroscopic applications of nonlinear optical phenomena such as harmonic generation, sum and difference frequency generation, stimulated Raman scattering, multiphoton absorption and ionization, and four-wave mixing methods such as coherent anti-Stokes Raman scattering. There are no prerequisites, but a background in molecular spectroscopy is recommended. Spring term odd-numbered years. 3 credit hours

CHEM-6470 Photochemistry
Physical and chemical consequences of interaction of visible and ultraviolet radiation with matter; laws of photochemistry; quantum mechanical description of light absorption; dynamics of excited state decay and energy transfer; organic photochemistry; experimental techniques and state-of-the-art applications. Spring term odd-numbered years. 3 credit hours

CHEM-6480 Chemical Kinetics
Kinetics of thermochemical and photochemical reactions. Mathematical and mechanistic descriptions of the phenomenological approach to rate process; theoretical treatments of kinetically simple reactions; principles of light absorption and photochemistry; organic photochemistry. Prerequisite: permission of instructor. Spring term odd-numbered years. 3 credit hours

CHEM-6490 Chemical Thermodynamics
The principles of thermodynamics, with their applications to homogeneous and heterogeneous equilibria. Prerequisite: permission of instructor. Offered on sufficient demand. 3 credit hours

CHEM-6510 Computational Chemistry
This course is designed to cover the history and applications of modern computational chemistry techniques to chemical problems. It will provide familiarity with the various methods and tools presently in use and the assumptions and limitations inherent in each approach. The format involves both lecture and studio modes of instruction and meets in a classroom where each student has a modern workstation. Spring term even-numbered years. 3 credit hours

CHEM-6520 Advanced Analytical Chemistry
A course in the principles of analytical chemistry emphasizing the role of equilibrium chemistry in chemical analysis and the statistical design of experiments. Topics covered include equilibrium chemistry, electrochemistry, chromatographic separations, thermal methods and chemometrics/experimental design. Spring term annually. 3 credit hours
Chem-6530 Quantum Chemistry  
Postulates of quantum mechanics. Solution of the particle in a box, harmonic oscillator, and the hydrogen atom via series solutions and ladder operator techniques. Development of atomic and molecular orbital theories with applications to structure and spectra. Fall term annually.  

3 credit hours

Chem-6540 Equilibrium Statistical Mechanics  
Principles of classical and quantum statistical mechanics with applications to thermodynamics, gases, and crystals. Included are topics related to phase and chemical equilibrium, chemical kinetics, imperfect crystals, surface layers, and electrolyte solutions. Prerequisite: Chem-6530 or permission of instructor. Full term odd-numbered years.  

3 credit hours

Chem-6620 Physical Chemistry of Macromolecular Solutions  
Thermodynamic properties of solutions of synthetic and natural macromolecules. Properties of solutions of non-electrolyte coiling polymers and of solutions of rigid and cooling polyelectrolytes with applications to the study of phase equilibrium, osmotic pressure, light scattering, equilibrium and velocity ultracentrifugation, translational diffusion, and intrinsic viscosity. Prerequisite: Chem-4620 or permission of instructor. Fall term even-numbered years.  

3 credit hours

Chem-6630 Synthesis of High Polymers I  
This course deals with the synthesis of high molecular weight polymers that proceed by condensation polymerization mechanisms. Detailed descriptions of characteristics and mechanisms of condensation polymerizations leading to various classes of polymeric materials will be provided. Discussion will center on the factors that are important for the control and commercial application of these polymerization techniques. Fall term alternate years.  

3 credit hours

Chem-6640 Polymer Science Laboratory  
Laboratory techniques and experiments in synthesis, characterization, and physical properties of high polymers. Some commercial polymers as well as those synthesized in the laboratory are investigated. Meets with Chem-4640; both courses cannot be taken for credit. Corequisite: Chem-4620 or equivalent or permission of instructor. Spring term annually.  

3 credit hours, 9 contact hours

Chem-6650 Synthesis of High Polymers II  
This course deals with the synthesis of high molecular weight polymers that proceed by addition polymerization mechanisms. Detailed descriptions of characteristics of free radical, cationic, anionic and coordination-catalyzed polymerizations will be provided. Discussion will center on the factors that are important for the control and commercial application of these polymerization techniques. Fall term alternate years.  

3 credit hours

Chem-6660 Polymer Analysis and Characterization  
The objective of this course is to provide the student with a broad survey of methods of analysis and characterization of polymers. Thermal analysis, molecular weight characterization, spectroscopy, and mechanical property determination will be reviewed with an emphasis on method of measurement, quantities measured, and quantities derived from the measurements. Select applications will be used to convey the usefulness of these methods for characterizing polymers and their properties. Spring term even-numbered years.  

3 credit hours

Chem-6780 Protein Folding  
The biophysical mechanism of protein folding and the role of misfolding in human disease is explored. The course will introduce principles of protein structure, protein folding in the cell, and thermodynamic and kinetic methods for studying protein folding in vitro. The course will also involve a literature-based discussion of human diseases related to protein folding defects, including Alzheimer’s and other amyloid diseases, cystic fibrosis, and Prion-related syndromes. Prerequisite or corequisite: Chem-4760 or BCBP-4760 or equivalent. Students may not receive credit for this course and BCBP-6780 or BCBP/Chem-4780. Fall term odd-numbered years.  

4 credit hours

Chem-6790 Protein Chemistry, Design and Modification  
The ability to design synthetic proteins from first principles (de novo design) is a new area of protein chemistry with exciting potential applications in medicine and industry. This course will review our present understanding of the chemistry and physics of protein structure and stability, and show how this understanding can be applied to the design of unnatural proteins. The course will also cover the computer modeling and chemical synthesis of proteins, how to impart new characteristics to natural proteins via chemical modification, and the generation of protein ‘chimera’ using semisynthesis. Prerequisite: Chem-4760 or BCBP-4760 or Biol-4760 or equivalent; Chem-6190 or BCBP-4810 is an asset. Cannot be taken for credit with BCBP-6790, Chem-4790 or BCBP-4790. Spring term, odd-numbered years.  

3 credit hours

Chem-6900 Chemistry Seminar  
Discussions and seminars on how to deal with the various aspects of teaching and related problems encountered by teaching assistants in Chemistry. Seminar topics will include: cognitive theories of learning; several models of teaching; educational psychology; attitude and motivational factors; communication and presentation skills; leadership; time management; how to write an exam; grading problems; ethics; group problem solving skills; and cul-  

1 credit hour

Chem-6910 Chemistry Teaching Seminar  
Discussions and seminars on how to deal with the various aspects of teaching and related problems encountered by teaching assistants in Chemistry. Seminar topics will include: cognitive theories of learning; several models of teaching; educational psychology; attitude and motivational factors; communication and presentation skills; leadership; time management; how to write an exam; grading problems; ethics; group problem solving skills; and cul-  

1 credit hour
tural diversity. Seminars will be led by a senior, experienced teaching assistant along with participating faculty. Graded satisfactory/unsatisfactory only. Fall term annually.  

**CHEM-6940 Readings in Chemistry**  
1 credit hour

**CHEM-6960 Selected Topics in Chemistry**  
1 to 3 credit hours

**CHEM-6970 Professional Project**  
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.  

3 to 4 credit hours

**CHEM-6990 Master's Thesis**  
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Up to 9 credit hours can be used in place of CHEM-6990 for students submitting a master's thesis.  

Variable credit hours

**CHME Chemical Engineering (SOE)**

**CHME-2010 Material, Energy, and Entropy Balances**  
Development of the ability to apply and solve equations of balance for chemical-process systems, laying the foundation for subsequent chemical engineering courses in unit operations and process design. Topics include process flowsheeting, mass and mole balances for nonreactive and reactive systems, properties of fluids, and the first and second laws of thermodynamics. Full term annually.  

4 credit hours

**CHME-2020 Energy, Entropy, and Equilibrium**  
A continuation of CHME-2010. Topics include process flowsheeting, solution thermodynamics, phase equilibria, chemical-reaction equilibria, and applications of thermodynamics to problems in chemical-process design. One credit hour of this course is devoted to Professional Development. Prerequisite: CHME-2010. Spring term annually.  

4 credit hours

**CHME-2940 Readings in Chemical Engineering**  
1 to 3 credit hours

**CHME-2960 Topics in Chemical Engineering**  
3 credit hours

**CHME-2980 Senior Project**  
1 to 3 credit hours

**CHME-4010 Fluid Mechanics and Heat Transfer**  
An introductory course in fluid mechanics and heat transfer covering fluid statics, laminar and turbulent flow and heat transfer in pipes and boundary layers, dimensional analysis, friction in valves and fittings, flowmeters, and heat conduction. Prerequisite: MATH-2400. Fall term annually.  

4 credit hours

**CHME-4020 Heat and Mass Transfer**  
An introductory course in heat and mass transfer covering radiation heat transfer, conduction and diffusion, heat exchanger design, packed towers, convective mass transfer, free convection, and change-of-phase heat transfer. Prerequisite: CHME-4010. Spring term annually.  

3 credit hours

**CHME-4030 Chemical Process Dynamics and Control**  
Introduction to modeling and control of dynamic chemical processes. Topics include the development of first-principles models, linearization and state space form, input/output (transfer function) form, design and tuning of PID controllers, model-based control, frequency response for robustness analysis, case studies in multivariable control, numerical analysis and simulation. Prerequisite: MATH-2400. Spring term annually.  

4 credit hours

**CHME-4040 Chemical Engineering Separations**  
The application of the fundamentals of chemistry, thermodynamics, mathematics, and transport phenomena to the design and evaluation of stage-wise and continuous contacting apparatus and systems for separating and purifying chemical materials. Steady-state and transient processes are studied. Prerequisites: CHME-4010 and CHME-4020. Corequisite or prerequisite: CHME-2020. Fall term annually.  

3 credit hours
CHME-4050 Chemical Process Design
The design of equipment, processes, and systems of interest in chemical engineering through application of scientific, technological, and economic principles. Emphasis is placed on problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. The work integrates knowledge and skills gained in previous and concurrent courses. This is a writing-intensive course. Prerequisites: CHME-4040 and CHME-4500. Spring term annually. 3 credit hours

CHME-4150, CHME-4160 Chemical Engineering Laboratory I, II
A two-term laboratory course on experimental analysis of the operations and processes of chemical engineering. Emphasis is placed on planning of experiments, data evaluation, and report writing. Prerequisites for CHME-4150: CHME-4010, CHME-4020, and CHME-2020. Prerequisites for CHME-4160: CHME-4150, CHME-4040, and CHME-4500. Fall and spring terms annually. 2 credit hours each

CHME-4400 Chromatographic Separation Processes
Theory and practice of chromatographic separation processes. Dynamics of zone migration, diffusion, and kinetics. Multicomponent adsorption, nonequilibrium adsorption, zone spreading, and control of separation. Modern analytical and preparative bioseparation techniques of liquid chromatography. Prerequisite: senior or graduate standing in chemical engineering or permission of instructor. Spring term annually. 3 credit hours

CHME-4430 Introduction to Biochemical Engineering
Description, fundamentals, and engineering features of processes using microbial, plant, or animal cells or their enzymes. Topics include review of biochemistry, review of microbiology, computer simulation, growth, death, aseptic techniques, continuous culture, fermenter design, sterilization, mixed cultures, process scale up, immobilized cells and enzymes, recovery of products, and process economics. Weekly exercises requiring personal computers. Prerequisite: background in chemical engineering or microbiology. Fall term annually. 3 credit hours

CHME-4500 Chemical Reactor Design
Principles of kinetics, reactor design, and analysis for both homogeneous and heterogeneous (catalytic) systems. Topics include design for multiple reaction networks (optimization selectivity), analysis of simple reactor combinations, and design of isothermal, adiabatic, and optimum temperature profile reactor. Prerequisites: CHME-2010, CHME-4010, and CHME-4020. Fall term annually. 3 credit hours

CHME-4600 Introduction to Semiconductor Processing
The basic processes used for fabrication of silicon-based semiconductor devices with emphasis on the chemical principles and systems involved. Topics include materials preparation, oxide growth, lithography, diffusion, ion implantation, epitaxial growth, chemical-vapor deposition, vacuum deposition, reactive ion etching, and packaging technologies. Fabrication of both bipolar and FET devices is discussed with emphasis on manufacturing process flow and control. Process design methodology. Prerequisite: senior standing in chemical engineering or permission of instructor. Fall term annually. 3 credit hours

CHME-4940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-4960 Topics in Chemical Engineering
3 credit hours

Graduate courses with Biochemical Engineering emphasis

CHME-6410 Advanced Membrane Concepts
An in-depth and comprehensive treatment of membrane technology. Membrane preparation and morphology. Models for transport through membranes. Fluid-dynamic phenomena across membrane systems. Particle dynamics, membrane fouling, and concentration polarization. Applications to chemical and biochemical separations. Critical reviews of the current literature. Prerequisite: a general knowledge of transport phenomena. Fall term even-numbered years. 3 credit hours

CHME-6420 Separation and Recovery Processes
The application of theoretical and fundamental principles and pilot plant data to the design and operation of biochemical separation processes and advanced waste treatment systems. Topics covered include characterization and dispersion, coagulation and flocculation, sedimentation, filtration, adsorption, ion exchange, membrane processes, aeration and gas transfer, centrifugation, and related subjects. Spring term annually. 3 credit hours

CHME-6430 Biochemical Engineering
Engineering aspects of microbial processes and of conversions with immobilized enzymes. Topics are mixed-culture processes, sterilization, aseptic techniques, mass transfer, bioprocess control, product isolation, enzyme technology, bioprocess development. There are heavy emphases on continuous fermentation and on chemicals from biomass. Prerequisite: microbiology or assigned reading. Fall term annually. 3 credit hours

CHME-6450 Advanced Biochemical Engineering
Selected topics beyond the scope of CHME-6430. Particular emphasis on the current literature and the applications of computers and graphics. Extensive coverage is given to purification and separation technology, kinetic
analysis, design of bioreactors, exploitation of genetic engineering, and bioprocess development. An individual project is required. Prerequisite: CHME-6430 or permission of instructor. Summer term annually.  

CHME-6470 Downstream Processing in Biochemical Engineering  
The course focuses on the concentration, recovery, and isolation of biological molecules relevant in biotechnology. The characteristics of biological molecules such as proteins and biological fluids such as blood, fermentation, and cell culture broth, are discussed. The principles, advantages, and limitations of centrifugation, membranes, cell disruption, two-phase extraction, precipitation crystallization, and electrical processes are discussed. Integrated bioseparation schemes are presented and many specific applications are discussed in detail. Prerequisite: a course in biochemical engineering or permission of instructor. Fall term odd-numbered years.  

Graduate courses with Chemical Engineering emphasis  

CHME-6510 Advanced Fluid Mechanics I  

CHME-6520 Advanced Fluid Mechanics II  
A continuation of CHME-6510. Treats irrotational flow, flow around bubbles, and other free surface problems, turbulent flow, jets, and wakes. Presumes an understanding of continuum mechanics, viscous flow, and boundary layer flow. Prerequisite: CHME-6510 or permission of instructor. Fall term odd-numbered years.  

CHME-6540 Convective Heat Transfer  
A review of basic concepts of mass, momentum, and energy conservation as related to convective heat transfer. The analysis of laminar and turbulent forces and free convection problems in both internal and external flows. Also a study of the current state of the art in boiling and condensation heat transfer. Spring term annually.  

CHME-6570 Chemical and Phase Equilibria  
Classical solution thermodynamics, equations of state, and topics in chemical reaction and phase equilibria. Emphasis is on the rigorous formulation of equilibrium problems, and on the measurement, reduction, correlation, and interpretation of experimental data. Fall term annually.  

CHME-6610 Mathematical Methods in Chemical Engineering I  
Development and application of mathematical methods for the solution of chemical engineering problems. Classical solution methods for ordinary and partial differential equations. Major emphasis is given to the mathematical implications of describing and solving representation of chemical reactors and other systems. Case studies relevant to other departmental graduate courses and ongoing research activities are discussed. The mathematical methods include series solutions, special function representations, boundary-value problems, and operational calculus. Prerequisite: MATH-2400. Fall term annually.  

CHME-6620 Mathematical Methods in Chemical Engineering II  
Modern solution techniques including semi-analytical, approximation, and numerical methods are introduced and applied to linear and nonlinear transport phenomena problems and chemical engineering systems. Similarity theory and integral methods, perturbation techniques, and orthogonal collocation, indispensable to chemical engineering, are discussed. Prerequisite: CHME-6610 or permission of instructor. Spring term annually.  

CHME-6640 Advanced Chemical Reactor Design  
Analysis of ideal and nonideal chemical reactor operation with simple and multiple homogeneous, heterogeneous, and catalytic reactions. Interplay of chemical and mass, energy and momentum transport processes in model reactors and catalytic particles. Topics include transient and steady-state operation, residence time distribution, multiplicity, stability, selectivity control, and catalyst deactivation. Prerequisite: CHME-4500 or permission of instructor. Spring term annually.  

CHME-6650 Advanced Process Control  
Application of modern control theory to chemical processes. Introduction to on-line data acquisition and computer control. Real-time process optimization and optimal control theory. Estimation theory and adaptive control. Introduction to stochastic control and to the control of large-scale distribution systems. Case studies via computer-aided design programs. Prerequisite: CHME-4030 or equivalent. Offered on sufficient demand.  

CHME-6660 Advanced Process Design  
Process synthesis with applications to heat exchange networks, energy-integrated separation sequences, and reactor networks. Analysis, design, and optimization of large-scale systems. Prerequisite: chemical engineering degree or permission of instructor. Offered on sufficient demand.
CHME-6830 Combustion
Review of fundamentals of thermodynamics, chemical kinetics, fluid mechanics, and modern diagnostics. Discussion of flame propagation, thermal and chain explosions, stirred reactors, detonations, droplet combustion, and turbulent jet flames. (Cross listed as MANE-6830. Students cannot receive credit for both this course and MANE-6830.) Prerequisite: permission of instructor. Spring term odd-numbered years. 3 credit hours

CHME-6840 An Introduction to Multiphase Flow and Heat Transfer I
This course is intended to give students a state-of-the-art understanding about single and multicomponent boiling and condensation heat transfer phenomena. Applications include the analysis of nuclear reactors, oil wells, and chemical process equipment. Students satisfactorily completing this course are expected to be able to thoroughly understand the current thermal-hydraulics literature on multiphase heat and mass transfer and be able to conduct independent research in this field. (Cross listed as MANE-6840. Students cannot obtain credit for both this course and MANE-6840.) Prerequisite: a working knowledge of fluid mechanics and heat transfer. Fall term annually. 3 credit hours

CHME-6850 An Introduction to Multiphase Flow and Heat Transfer II
This course is intended to give students a state-of-the-art understanding in multicomponent flow phenomena. Applications in the chemical process, petroleum recovery, and fossil/nuclear power industries will be given. Specific areas of coverage include two-phase: fluid mechanics, pressure drop, modeling and analysis, stability analysis, critical flow and dynamic waves, flow regime analysis, and phase separation and distribution phenomena. (Cross listed as MANE-6850. Students cannot obtain credit for this course and MANE-6850.) Prerequisite: CHME-6840 or MANE-6840. Spring term annually. 3 credit hours

CHME-6940 Readings in Chemical Engineering
1 to 3 credit hours

CHME-6950 Topics in Chemical Engineering
State-of-the-art formal courses in specialized areas suitable for master’s and doctoral programs. Usually two topics offered per term. Typical topics include colloidal dynamics, dispersion and mixing, fluidation, heterogeneous catalysis, polymer reaction engineering, stochastic processes, and statistical mechanics. Fall and spring terms annually. 1 to 3 credit hours

CHME-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CHME-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 16 credit hours

CHME-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 16 credit hours

CISH Computer Science at Hartford (SOS)

CISH-4010 Discrete Mathematics and Computer Theory*
This course covers foundations of discrete mathematics and fundamentals of computer theory. Topics include propositional logic, truth tables, quantifiers, sets, set operations, sequences, complexity of algorithms, divisibility, matrix manipulations, proofs, induction, recursion, counting and the pigeonhole principle, permutations, combinations, repeated trials, expectation, relations (properties, representation, equivalence, Warshall’s algorithm), Boolean algebra, functions, logic gates, minimizing, Finite State Machines, Turning machines, Regular expressions, context free grammars, language recognizers, derivation trees, pushdown automata. H and G, fall term annually; H, spring and summer term. 3 credit hours

CISH-4020 Object Structures*
A study of object oriented software component design. This course introduces the object oriented paradigm and its use in organizing software structures including arrays, stack, queues, lists, trees, graphs, and recursion. Programming assignments require the use of an object oriented language. Prerequisite: CISH-4010 or equivalent and knowledge of an imperative programming language (C, PASCAL, etc.). 3 credit hours

*C This is an “immigration” course which will not count towards the M.S. in Computer Science, M.S. in Information Technology, or M.Eng. in Computer and Systems Engineering degrees. Such courses may count towards other degrees but consult with your adviser before registering.
CISH-4030 Structured Computer Architecture*
Introduction to computer architecture; the structure and function of a computer system consisting of processors, memory, I/O modules, and its internal interconnections. Primary focus on the attributes of a system visible to an assembly level programmer. Topics include: digital logic, VLSI components, instruction sets, addressing schemes, memory hierarchy, cache and virtual memories, integer and floating point arithmetic, control structures, buses, RISC vs. CISC, multiprocessor and vector processing (pipelining) organizations. Examples are drawn from contemporary (e.g., Intel Pentium, PowerPC) microcomputers.
3 credit hours

CISH-4940 Readings in Computer and Information Sciences
1 to 4 credit hours

CISH-4960 Topics in Computer and Information Sciences
1 to 4 credit hours

CISH-4961 Introduction to Computer Programming*
Presents a robust introduction to computer science with a strong emphasis on the discipline of computer programming. Students will use a high level language to complete a substantial number of programming assignments which will be assigned for homework and as in-class workshops. Classroom lectures will focus on program design and efficiency techniques. Lectures will also present a survey of other major computer science topics including operating systems, object oriented programming and design, telecommunications, the Internet and intranets, database management and graphical user interfaces. Prerequisite: Basic PC literacy.
3 credit hours

CISH-6010 Object Oriented Programming and Design
An introduction to the theory and practice of object oriented programming and design. Encapsulation, inheritance, genericity, dynamic binding, and polymorphism. Students use these concepts to design and implement a modest-sized system. One object oriented language (chosen by the instructor) is studied in detail and required for the project. Other languages are covered briefly. Prerequisite: CSCI-4210.
3 credit hours

CISH-6020 Object Oriented Paradigm
A continuation of the topics and concepts covered in Object Oriented Programming and Design, which serves as a prerequisite. Students design and implement a modest system using an established OO design technique introduced in class and the language of their choice. In addition, students survey the current OO literature and produce an expository paper based on their research. Classroom presentations of designs and research may also be required. Prerequisite: CISH-6010.
3 credit hours

CISH-6050 Software Engineering Management
Introduction to the current issues in software engineering management. Topics include the origin of the software crisis, current state-of-the-practice, modeling the software engineering process, the relationship of methods and tools to process, software validation, risk mitigation, and software engineering economics.
3 credit hours

CISH-6110 Object Oriented Database Systems
Presents concepts and architectures of object oriented database systems. Provides the object oriented view of data models, query languages, versioning evolution, authorization, transaction control, storage management, indexing techniques, distributed data, and parallelism. Current object oriented database systems are reviewed and compared. A programming project or research paper may be required. Prerequisites: CSCI-4380 and the object oriented portion of either CISH-4020 or CISH-6010.
3 credit hours

CISH-6120 Distributed Database Systems
Examines client/server DBMS and considers how a clientserver architecture can be used to implement the requirements of a DDBMS. Topics include DDBMS taxonomies, case studies, design considerations, transaction management, and global query optimization. Concludes with an examination of multidatabase systems. Prerequisite: CSCI-4380.
3 credit hours

CISH-6210 Computer Network Analysis and Design
Mathematics modeling and analysis of multiplexing and switching systems in computer communication networks. Topics include: queues and networks of queues. Multiplexing, CSMA and token passing techniques for LANs, protocols for congestion and flow control, and algorithms for routing and flow allocation. Prerequisite: ECSE-4670.
3 credit hours

CISH-6220 LANs, MANs, and Internetworking
Examines client/server DBMS and considers how a client-server architecture can be used to implement the requirements of a DDBMS. Topics include DDBMS taxonomies, case studies, design considerations, transaction management, and global query optimization. Concludes with an examination of multidatabase systems. Prerequisite: CSCI-4380.
3 credit hours

CISH-6230 Network Management
Introduction to methods, techniques, and tools for the management of telecommunication systems and networks. Major topics covered in the course are: Simple Network Management Protocol (SNMPv2, SNMPv3), Remote Monitoring (RMON1, RMON2), Standard Management

* This is an “immigration” course which will not count towards the M.S. in Computer Science, M.S. in Information Technology, or M.Eng. in Computer and Systems Engineering degrees. Such courses may count towards other degrees but consult with your adviser before registering.
Information (MIBs), and Telecommunications Management (TMN, CMIS/CMIP); configuration and name management; fault and performance management; security; accounting management; and Web-based network management. Prerequisite: ECSE-4670 or equivalent basic concept computer and communication networks course.  

**CISH-6510 Web Application Design and Development**  
Students will learn approaches to the design, development, and maintenance of Web sites. Students will study software and information architectures for the Web, design techniques for distributed Web-based applications, and methods and tools for the creation and maintenance of Web sites. Study will encompass the major components of a Web site, including browsers and client applications, Internet protocols that link the client to the server, and server applications. Issues of performance, security, and usability will be examined. Prerequisites: CISH-4020 or CISH-2300, prior experience with HTML and Java, ECSE-4670 and CSCI-4380 recommended. Fall and spring terms annually.  

**CISH-6900 Computer Science Seminar**  
For students near the end of their program, a two-semester course that meets once per month from September through March and one Saturday in April when students give their presentations. Registration is accepted during fall registration only. Students are required to attend all eight meetings in order to fulfill the Seminar requirement. This course, combined with two additional graduate credit hours, will be the equivalent of one advanced three-credit-hour elective.  

**CISH-6940 Readings in Computer and Information Sciences**  
1 to 3 credit hours  
**CISH or CSCI-6960 Topics in Computer and Information Sciences**  
1 to 3 credit hours  
**CISH-6970 Professional Project**  
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  

**CISH-6990 Master’s Thesis**  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  

**CIVL Civil Engineering (SOE)**  
**CIVL-2030 Introduction to Transportation Engineering**  
Introduction to the planning, design, and analysis of transportation problems. Studies of costs of providing transportation, level of service offered to travelers, and demand for transportation services. Evaluation of various service strategies and the policy implications of each alternative. Various modes of travel and their physical facilities. Prerequisite: MATH-2400. Corequisite: ENGR-2600. Fall term annually.  

**CIVL-2040 Professional Practice**  
Contract essentials; types of contracts for construction and for engineering services. Bidding procedure, surety bonds, insurance, litigation. Standard contract documents, the compilation of specifications. Engineering ethical principles and codes. Fall term alternate years.  

**CIVL-2130 Surveying**  
The organization, planning, instrumentation, and execution of surveys for engineering projects including precise control systems for both horizontal and vertical control, astronomical observations for the establishment of precise directions, terrestrial and photogrammetric mapping, statewide plane coordinate systems, and the legal aspects of boundary surveys. Fall term alternate years.  

**CIVL-2630 Introduction to Geotechnical Engineering**  
The application of the basic laws and phenomena of science to particulate matter, specifically soils. Basic physical and mechanical structural characteristics of soil. Equilibrium and movement of water. Flow through porous media. Effective stress. Stress-strain-time relations. Basic laboratory work as related to practice. Prerequisite: ENGR-2530. Fall term annually.  

**CIVL-2670 Introduction to Structural Engineering**  
Introduction to the elastic behavior of structural components. Analysis of statically determinate systems. Deflection calculations by virtual work and elastic load methods. Analysis of simple statically indeterminate structures. Influence lines. Interaction of structural compo-
CIVL-4140 Geoenvironmental Engineering
The application of geotechnical engineering to the environmental area. Deals with waste disposal, waste containment systems, waste stabilization and landfills. Emphasis on design of such facilities. Includes related topics necessary for design, e.g., geosynthetics, groundwater, contaminant transport and slurry walls. Some field trips are possible. (Students cannot receive credit for both this course and CIVL-6550.) Fall term annually. 3 credit hours

CIVL-4150 Experimental Soil Mechanics
Second course in geotechnical engineering, emphasizing experimental aspects of soil behavior. Laboratory experiments to measure the following soil properties: consolidation, compressibility, shear strength, permeability, various moduli, and bearing capacity. Theory, practical applications of theory, and laboratory. Prerequisite: CIVL-2630 or equivalent. Spring term annually. 3 credit hours

CIVL-4240 Introduction to Finite Elements
An introductory course in use of the Finite Element Method (FEM) to solve one- and two-dimensional problems in fluid mechanics, heat transfer, and elasticity. The methods are developed using weighted residuals. Algorithms for the construction and solution of the governing equations are also covered. Students will be exposed to the use of commercial finite element software. (Cross listed as MANE-4240. Students cannot obtain credit for both this course and MANE-4240.) Prerequisites: ENGR-2530 or equivalent. Fall term annually. 3 credit hours

CIVL-4270 Construction Management
Application of engineering principles to planning construction operations. Network scheduling (CPM, PERT), resource allocation. Cost engineering and control. Prerequisite: senior standing. Spring term annually. 3 credit hours

CIVL-4440 Structural Analysis
Computer analysis of structures. Advanced topics in the behavior of structural components. Bending of plates, buckling of columns and frames. Beam-columns. Torsion in structural members. Inelastic behavior and limit analysis of structures. Prerequisite: CIVL-2670. Fall term annually. 3 credit hours

CIVL-4570 Analytical Methods in Infrastructure Engineering
Analysis methods and software used to manage highway and transit systems, pipeline systems, building campuses, and other large networks of civil engineering structures. Topics include: performance evaluation and forecasting, life-cycle cost analysis, capital programming and budget allocation, optimization, databases and management systems, information and knowledge modeling, expert systems, decision analysis techniques, and uncertainty in decision making. Prerequisite: CIVL-4580 or equivalent professional experience. Spring term annually. 3 credit hours

CIVL-4580 Infrastructure Engineering
Principles and fundamental analytical methods required for the preservation of the civil engineering infrastructure. Included are determination of condition of existing struc-
CIVL-4620 Mass Transit Systems
The basic concepts of planning, design, and operation of urban mass transit systems. Topics include travel demand, network configurations, communication and control systems, power systems, vehicle technology, guideway and vehicle support and guidance technology, routing and scheduling, operating practice, marketing and financing of transit service, interface design, and implementation. These topics are discussed with relation to bus transit systems, guided transit systems, and several new systems. Several case studies examined. Prerequisite: CIVL-2030. Spring term odd-numbered years. 3 credit hours

CIVL-4640 Transportation Facility Design and Planning
Approaches to the planning, design, and engineering of airports, rail yards, and marine terminals. Special attention is paid to the operational requirements of each mode of transportation and the impact these have on facility design. Innovative designs are encouraged through a series of design projects. Prerequisite: CIVL-2030. Spring term odd-numbered years. 3 credit hours

CIVL-4660 Traffic Engineering
Basic characteristics of traffic, including driver, vehicle, volume, speed delay, capacity, and accidents; traffic surveys, administration, laws and ordinances; traffic regulation and control, signs, markings, signals, and signal systems. Prerequisite: CIVL-2030. Fall term annually. 3 credit hours

CIVL-4670 Highway Engineering
Principles of geometric design of highways, intersections, interchanges, and terminals. Practical issues of vertical and horizontal curvature, highway evaluation, driver and vehicle dynamics, and traffic safety are also addressed. Computer-aided design and modeling. Prerequisite: CIVL-2030. Spring term even-numbered years. 3 credit hours

CIVL-4920 Civil Engineering Capstone Design
Open-ended design project in which students work in teams. Oral presentations and written reports cover alternatives considered, design assumptions, cost, safety, and feasibility. This is a writing-intensive course. Prerequisites: senior status and CIVL-4070 and CIVL-4080, or CIVL-4010 and CIVL-4150, or CIVL-2030 and CIVL-4660 or CIVL-4640. Spring term annually. 3 credit hours

CIVL-4940 Readings in Civil Engineering
1 to 3 credit hours

CIVL-4960 Topics in Civil Engineering
3 credit hours

CIVL-6170 Mechanics of Solids
Introduction to Cartesian tensors, infinitesimal strain kinematics, equations of motion. Models of material behavior: isothermal linear isotropic and anisotropic elasticity, thermoelasticity, linear viscoelasticity and rate-independent plasticity. General principles in elasticity: minimum potential and complementary energy, reciprocal theorem. Formulation of linear elastic boundary value problems, methods of solutions for 2-D and 3-D elasticity problems. Correspondence principle of linear viscoelasticity, applications to simple structural components. Use of symbolic computations in the solution of BVP. (Cross listed as MANE-6170. Students cannot obtain credit for both this course and MANE-6170.) Spring term annually. 3 credit hours

CIVL-6180 Mechanics of Composite Materials
Micromechanics of elastic heterogeneous solids. Plasticity of composite materials. Thermoelastic and thermoplastic behavior. Mechanics of distributed damage. Mechanical behavior. (Cross listed as MANE-6180. Students cannot obtain credit for both this course and MANE-6180.) Prerequisite: one graduate course in mechanics of solids. Fall term annually. 3 credit hours

CIVL-6200 Plates and Shells
Prerequisites: CIVL-2030, ECON-2010, and DSES-4140. Pertinent current problem areas, cost/benefit analysis. Theory, demand analysis, cost analysis, pricing, regulation, economic theory, as they apply to transportation. Location administration, laws and ordinances; traffic regulation and control, signs, markings, signals, and signal systems. Prerequisite: CIVL-2030. Fall term annually. 3 credit hours

CIVL-6210 Structural Stability
Concepts of stability pertaining to structural and mechanical systems. Static and dynamic theories of stability. Configurations include bars, plates, shells, and structural complexes. (Cross listed as MANE-6210. Students cannot obtain credit for both this course and MANE-6210.) Annually. 3 credit hours

CIVL-6230 Transportation Economics
Economic concepts, drawn from micro- and macro-economic theory, as they apply to transportation. Location theory, demand analysis, cost analysis, pricing, regulation, pertinent current problem areas, cost/benefit analysis. Prerequisites: CIVL-2030, ECON-2010, and DSES-4140 or their equivalents. Fall term even-numbered years. 3 credit hours

CIVL-6240 Intelligent Transportation Systems
This course covers concepts and models applicable to intelligent transportation systems (ITS). ITS uses information system technology to create seamless multi-modal transportation systems with enhanced performance and productivity. Term projects focus on assessment and evaluation of candidate ITS treatments for site-specific locations based on network models that capture real-time phenom-
torsional design. Effects of semi-rigid connections on structural stability. Prerequisite: CIVL-4070 or equivalent. Spring term annually. 3 credit hours

CIVL-6450 Structural Dynamics
Analysis of elastic and inelastic single and multiple degree-of-freedom structural systems under time-dependent loads including harmonic, impulse, earthquake, and other general dynamic loads. Development of equations of motion. Analytical and numerical evaluation of free and forced vibration response. Identification of dynamic system properties; Modal analysis. Vibration isolation and force transmissibility. Dynamic measurement sensors. Shock loading spectrum. Frequency-domain analysis. Prerequisite: CIVL-4440. Fall term annually. 3 credit hours

CIVL-6460 Advanced Structural Dynamics
Stochastic response of lumped parameter and continuous systems to random excitation, wave propagation, power spectral densities, covariance and cross covariance functions, transfer functions, application of procedure to wind and earthquake engineering. Review of current literature. Prerequisite: CIVL-6450. Spring term alternate years. 3 credit hours

CIVL-6480 Designing with Geosynthetics
Civil Engineering applications of geosynthetics including geotextiles, georings, geosets, geocell membranes, geosynthetic clay liners, geopipe and geocomposites. Designing by function, including separation, reinforcement, filtration, drainage, liquid barrier, and combined functions. Applications in the areas of landfills, groundwater drains, geotextile reinforced walls and slopes, roadways, and other civil engineered type structures. Prerequisite: CIVL-2630 or equivalent. Spring term alternate years. 3 credit hours

CIVL-6490 Earthquake Engineering
Seismology concepts including plate tectonics, fault mechanics, quantification of earthquake size, and wave propagation. Dynamic sensors for earthquake ground motion measurement. Estimation of ground motion parameters using attenuation relationships. Linear and nonlinear dynamic analyses for evaluation of the seismic response of structures. Code-based approach to the seismic analysis and design of structural systems. Seismic design considerations for various construction materials. Base isolation and energy dissipation systems for seismic protection of structures. Prerequisite: CIVL-6450. Spring term alternate years. 3 credit hours

CIVL-6510 Advanced Soil Mechanics
An intensive study of the fundamentals of soil mechanics at the graduate level. Transmission of stresses between particles. Soils in which the pore water is either stationary or flowing under steady conditions. Soils in which pore pressures are influenced by applied loads, and hence the pore water is flowing under transient conditions. Prerequisite: CIVL-4150. Fall term annually. 3 credit hours
CIVL-6520 Advanced Foundations and Earth Structures
The applications of the principles of soil mechanics to the design of foundations, at the graduate level. Subsurface investigation. Design of footings, retaining walls, pile foundations, flexible retaining structures, anchor tie-backs, bridge piers, abutments, embankments and natural slopes. Slope stability analysis and landslide prevention. Earthquake effects. Case studies. Prerequisites: CIVL-4010, CIVL-4150. Spring term annually. 3 credit hours

CIVL-6530 Seepage, Drainage, and Groundwater
Introduction to groundwater hydrology, well hydraulics, permeability, seepage, flow nets, filter criteria, dewatering, slope stabilization, practical applications. Prerequisite: CIVL-2630 or equivalent. Spring term alternate years. 3 credit hours

CIVL-6540 Dynamics of Soil and Soil-Foundation Systems
Basics of dynamic response of soil and soil-foundation systems, including applications to earthquake engineering and machine foundations. Systems studies include shallow and deep foundations, buried structures, earth structures, slopes, and earthquake site response. Prerequisite: CIVL-6450. Spring term annually. 3 credit hours

CIVL-6550 Advanced Geoenvironmental Engineering
An intensive study of the application of geotechnical engineering to the environmental area. Deals with waste disposal, waste containment systems, waste stabilization and landfills. Emphasis on design of such facilities. Includes related topics necessary for design, e.g., geosynthetics, groundwater, contaminant transport, and slurry walls. Some field trips are possible. This course meets concurrently with CIVL-4140. CIVL-6550 students are required to do a term paper and/or project, read additional professional papers and publications, and do additional laboratory experiments. (Students cannot receive credit for both this course and CIVL-4140.) Fall term annually. 3 credit hours

CIVL-6660 Fundamentals of Finite Elements
Graduate-level course on the fundamental concepts and technologies underlying finite element methods for the numerical solution of continuum problems. The course emphasizes the construction of integral weak forms for elliptic partial differential equations and the construction of the elemental level matrices using multi-dimensional shape functions, element level mappings and numerical integration. The basic convergence properties of the finite element method will be given. This course serves as preparation for students working on finite element methods. (Cross listed as MANE-6660. Students cannot obtain credit for both this course and MANE-6660.) Prerequisite: differential equations. Fall term annually. 3 credit hours

CIVL-6670 Nonlinear Finite Element Methods
The formulations and solution strategies for finite element analysis of nonlinear problems are developed. Topics include the sources of nonlinear behavior (geometric, constitutive, boundary condition), derivation of the governing discrete equations for nonlinear systems such as large displacement, nonlinear elasticity, rate independent and dependent plasticity and other nonlinear constitutive laws, solution strategies for nonlinear problems (e.g., incrementation, iteration), and computational procedures for large systems of nonlinear algebraic equations. (Cross listed as MANE-6670. Students cannot obtain credit for both this course and MANE-6670.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years. 3 credit hours

CIVL-6680 Finite Element Programming
Examines the implementation of finite element methods. Consideration is first given to the techniques used in classic finite element programs. Attention then focuses on development of a general geometry-based code which effectively supports higher order adaptive technique. Technical areas covered include: effective construction of element matrices for p-version finite elements, ordering of unknowns, automatic mesh generation, adaptive mesh improvement, program and database structures. Implementation of automated adaptive techniques on parallel computers is also covered. (Cross listed as MANE-6680. Students cannot obtain credit for both this course and MANE-6680.) Prerequisite: CIVL-6660, MANE-6660, CSCI-6860 or MATH-6860. Spring term odd-numbered years. 3 credit hours

CIVL-6690 Advanced Finite Element Formulations
This course focuses on generalized weighted residual methods and multifield variational principles for constructing approximate solutions to sets of governing differential equations and associated boundary conditions. Topics include hybrid and mixed methods, boundary element formulations, p-version finite elements, global/local procedures, and penalty methods. Problem areas include solid mechanics (nearly incompressible solids, plates, and shells), fluid mechanics including compressible flows, and heat transfer. (Cross listed as MANE-6690. Students cannot obtain credit for both this course and MANE-6690.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years. 3 credit hours

CIVL-6700 Finite Element Methods in Structural Dynamics
Solutions to the free vibration and transient dynamic responses of two- and three-dimensional structures by the finite element method are considered. The governing finite element matrix equations are derived and numerical aspects of solving these time-dependent equations con-
CIVL-6780 Numerical Modeling of Failure Processes in Materials
State-of-the-art in computational modeling of failure processes in materials. Topics include numerical modeling of discrete defects, distributed damage and multiscale computational techniques including multiple scale perturbation techniques, boundary layer techniques, and various global-local approaches. (Cross listed as MANE-6780.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years. 3 credit hours

CIVL-6900 Civil Engineering Graduate Seminar
Civil engineering graduate students present seminars about their research to an audience composed of students and faculty and participate in discussions about the research of others. The course consists of one-hour weekly meetings. The faculty member in charge of the course helps the students develop their presentation skills. This course is required to be taken once by master’s students and twice by Ph.D. students. Spring term annually. 0 credit hours

CIVL-6940 Readings in Civil Engineering
1 to 3 credit hours

CIVL-6960 Topics in Civil Engineering
3 credit hours

CIVL-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CIVL-6980 Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the Master’s Project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

CIVL-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

COMM Communication (HSSH)

COMM-1510 Introduction to Communication Theory
This course focuses on topics, theories, and research methods central to the study of human communication. The following kinds of issues and topics are considered: definitions/models of communication; what it means to use a language; how language affects the way we see the world; ancient and contemporary communication media; non-verbal communication; interpersonal and small-group communication. Fall and spring terms annually. 4 credit hours

COMM-2410 Perspectives on Photography
This course helps students understand the meaning and emotional complexity of visual images in our culture. Students examine photographic imagery through three perspectives. The first—formal—addresses the design components of the image, such as vantage point and contrast. The second—psychodynamic—concerns the emotional dynamics of viewing. The third—social political—explores photographs as instruments for preserving or challenging cultural values. No technical knowledge of photography is needed. Offered annually. 4 credit hours
COMM-2460 Media and Popular Culture
A general survey of contemporary media, their historical origins and social impact, with a focus on TV, newspapers, magazines, radio, film, and personal computers. Spring term annually.

COMM-2610 Introduction to Visual Communication
This course is an introduction to basic principles of visual communication and an exploration of the graphic design process. The study approach is through laboratory work utilizing software applications currently used in the field. Topics include type and image, logo design and application, foundation statement creation, and print production methods. Fall and spring terms annually.

COMM-2880 Interpersonal Communication
A course examining communication processes between two individuals in a variety of contexts including friendships, families, and work relationships. Considers both scientific and humanistic approaches to interpersonal communication. Topics discussed include development of the self, interpersonal attraction, social exchange theory, family communication systems, conflict, and communication skills. Fall term alternate years.

COMM-2940 Communication Studies
Readings and projects adapted to the needs of individual students.

COMM-2960 Topics in Communication
Experimental courses tried out in one or two terms.

COMM-2610 Introduction to Visual Communication
This course is an introduction to basic principles of visual communication and an exploration of the graphic design process. The study approach is through laboratory work utilizing software applications currently used in the field. Topics include type and image, logo design and application, foundation statement creation, and print production methods. Fall and spring terms annually.

COMM-3470 Electronic Coaching Systems
This course is based on theoretical work in cognition and motor behavior and on applied research in computing, sports, and arts. This course analyzes how designers think about human performance systems. Support systems analyzed include online tutorials, wizards, agents, and Web-based systems. Prerequisite: COMM-4750 or another LL&C 4000-level graphics or document design course, or graduate standing. Spring annually.

COMM-4400 Publication Practicum
This course is an advanced design studio course about how to integrate type and image when creating social communications for and with an audience. Students are guided step-by-step through the communication design process from conception to production. In a participatory manner and through readings they learn how to communicate visually to a multicultural audience. Fall term annually. Prerequisite: COMM-4570. Cross listed with COMM-6430. Students cannot obtain credit for both courses.

COMM-4420 Foundations of HCI Usability
In this course we will consider methods of gathering users’ requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. We will design and conduct usability tests on products, documents, and interfaces of interest. Cross-listed with COMM-6420; an additional assignment is required for COMM-6420. Students cannot obtain credit for both courses.

COMM-4300 Communication Internship
This course is designed for communication majors who wish to incorporate field experience in their educational programs. Students work with local business, industrial, civic, or educational organizations in positions where they can observe communication processes and apply written, interpersonal, and public communication skills to the solution of real problems. Prerequisite: undergraduate major in communication at junior or senior level or graduate status. Fall and spring terms annually.

COMM-4340 Communication in Cyberspace
This course involves students from multiple locations in the study of issues pertaining to forms and social effects of computer-mediated communication (CMC). Through both study and significant “hands-on” use of such systems, students learn to manage various network-based communication systems through collaborative projects in virtual teams through electronic partnership. Theories and illustrations regarding the impacts of CMC in relation to organizational communication and structure, group communication and decision making, and interpersonal effects are explored. Prerequisite: IHSS-196X or equivalent. Offered spring semester, alternate years.

COMM-4400 Publication Practicum
This course is designed for communication majors who wish to incorporate field experience in their educational programs. Students work with local business, industrial, civic, or educational organizations in positions where they can observe communication processes and apply written, interpersonal, and public communication skills to the solution of real problems. Prerequisite: undergraduate major in communication at junior or senior level or graduate status. Fall and spring terms annually.
COMM-4560 Media and Popular Culture
A survey of the historical origins and cultural impact of several mass media, including television, film, radio, the internet, and print media. The course aims to increase media literacy through analysis of specific media products as well as discussion of broad topics such as: advertising and commercialization; politics and censorship; gender, race, and social identity. Prerequisite: any COMM or LITR course, graduate standing, or permission of instructor. Spring term annually. 4 credit hours.

COMM-4570 Typography
Text that isn’t noticed isn’t read. Typography is a studio course in graphic design that teaches students the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in any given composition. Designing emotive, aesthetically pleasing, and persuasive typographic compositions is the focus of the course. (Cross listed with COMM-6570. Students cannot obtain credit for both courses.) Prerequisite: COMM 2610. Spring term annually. 4 credit hours.

COMM-4580 Advertising and Culture
An examination of the cultural impact of advertising in various media: TV, radio, print, and the Web. How does advertising inform our experience and identity? How has it shaped our culture? Who pays for it and why? These are the types of questions this course will address. Prerequisite: any COMM or LITR course or permission of instructor. Fall term annually. 4 credit hours.

COMM-4590 Research Design and Analysis for New Media
A practicum in research focusing on methodology for assessing Web usage and computer-mediated behavior. Topics include research design issues, data gathering, sample frames, recruitment and treatment of subjects and quantitative analysis of online surveys, server bits, and other forms of direct and unobtrusive data. Prerequisite: at least one previous 4000-level research course; one course in statistics is advisable. Offered upon availability of instructor. 4 credit hours.

COMM-4600 Rhetoric of Nature and the Environment
A seminar course focusing on how attitudes are formed and people mobilized to action on environmental issues. Topics will include traditions of nature writing and art, the symbolic/conceptual formation of “nature” and “the environment,” and methods for analysis and development of discursive formations and persuasive strategies. Prerequisites: junior or senior status, two environmentally focused H&SS courses, and two courses in biology and/or geology, or permission of the instructor. Spring term annually. 4 credit hours.

COMM-4610 Rhetorical Analysis
A study of the persuasive use of language. Some basic theories of argument and style are explored as a means of improving the students’ ability to both analyze and create rhetorical discourse. Prerequisite: WRT-2110 or permission of instructor. Offered on availability of instructor. 4 credit hours.

COMM-4640 Language and Power
Language plays a key role in the creation and reproduction of social inequalities across groups and between individuals. This course explores the linguistic dimensions of colonialism; race, ethnic, gender, and class differences in communicative style; access to institutional resources such as jobs, justice, health care, and education; media manipulation; and the uses of religious rhetoric for political ends. Students learn how to gather and analyze real-life conversations. Prerequisite: permission of instructor. Spring term annually. 4 credit hours.

COMM-4650 Intermediate Visual Communication
This is a studio course that grapples with advanced applications of the basic principles of design in print and electronic media. The focus of the course is on developing the student’s ability to derive viable concepts in the creation of meaningful, communicable, and aesthetically pleasing communication forms. Situated in a computer lab, students complete hands-on projects, thumbnail sketching by hand and using the computer as a tool. Prerequisite: COMM-2610. Spring term annually. 4 credit hours.

COMM-4660 Visual Literacy
This is an intermediate design studio course about visual literacy theory and its practical application to the creation of graphic designs that communicate to an audience. Students hone their conceptual and creative skills through rigorous visual problems that they solve individually and then analyze in group critiques. Fall term annually. Prerequisite: COMM-2610 and COMM-4570. Cross listed with COMM-6xxx. Students cannot obtain credit for both courses. 4 credit hours.

COMM-4660 Introduction to Hypermedia Computing
This course is an introduction to hypermedia design and development, focusing on user interface design for interactive multimedia programs. Special emphasis will be placed on the theoretical issues behind effective user interface design. Students will have an opportunity to put theory into practice. Prerequisite: an introductory course in communication, another social science course, or permission of the instructor; basic knowledge of authoring software for multimedia or Web development. Spring term annually. 4 credit hours.
COMM-4720 Web Designing for Community Networking
This course emphasizes participatory design and the development of functional communication products for real-world clients. Students create Web-based graphic, interactive, or multimedia information resources for arts and cultural organizations, city and county government, and social-service organizations in Troy, New York. These resources may be used by the Troy Coalition for Community Networking and TroyNet. Prerequisite: at least one course in database, multimedia, or Web design. Spring term annually.  4 credit hours

COMM-4750 Electronic User Interfaces
Application of research on computer usability to the design of Web sites, graphic user interfaces (GUIs), personal digital assistants (PDAs), persuasive computing, and electronic performance support systems. Prerequisite: an introductory course in communication or another social science. Fall term annually.  3 credit hours

COMM-4760 Task-Oriented Communication
Teaches the practices of developing instructions for people performing mental and physical tasks. This course covers evaluating task performance, choosing instructional media, developing instructional objectives, and producing procedural information. Attention is given to graphic media and to nonverbal tasks and skills. Prerequisite: an introductory course in communication or another social science. Spring term, alternate years.  4 credit hours

COMM-4770 - User-Centered Design
Explore how users get involved in design: as specifiers of requirements, as evaluators, as sounding boards, and as collaborators. We will gather requirements, design to meet those requirements, and evaluate our success. Cross-listed with COMM-6770; students taking COMM-6770 will be assigned an additional project. Students cannot obtain credit for both courses. Prerequisites: COMM-4420 or permission of instructor. Spring Term Annually.  4 credit hours

COMM-4780 Hypermedia Art and Fiction: Theory and Design
This course is a seminar for students with some experience designing interactive multimedia computer programs (or Web sites). The seminar will explore new directions in interactive electronic art, in particular, audiovisual artworks and hypertext fiction. Students will evaluate how interactive electronic media can be used for creative expression and present their findings in oral presentations and written reports. For final projects, students will have the option of completing either a research paper or an interactive electronic project. Prerequisite: previous experience designing interactive multimedia computer programs (or Web sites). Fall term annually.  4 credit hours

COMM-4790 Social Impact of Electronic Media
An exploration of the effects of electronic media such as the Internet, multimedia, computers, pop music, and television. The effects examined include changes in social and work relationships, time displacement, audience aggression, child socialization, education, and consumer behavior. Prerequisite: any communication course or permission of the instructor. Offered on availability of instructor.  3 credit hours

COMM-4800 Media and Memory
Stories of the past are always told in some specific present, with emphases and interests grounded in that present. Collective memory is thus reshaped continuously as people fashion social realities that conform to their values and beliefs. This course focuses on the rhetorical formation of collective pasts, emphasizing the role of communication media in the process. Cross listed with COMM-6800. Students cannot obtain credit for both courses. Prerequisites: one WRIT course and one COMM course. Spring term annually.  4 credit hours

COMM-4810 Electronic Media and Society
Electronic media such as the Internet, cable television, movies, and pop music are both producers of information and large organizational structures. The course analyzes the interplay between media organizations and society at large. Offered on availability of instructor.  4 credit hours

COMM-4830 Organizational Communication
Focuses on the central role of communication in organizations by exploring the way that communication is used in exercising authority, power, and control. Organizations with hierarchical and nontraditional structures are considered. The course also examines the role of communication in the social construction of organizational life. Prerequisite: an introductory course in the social sciences or management or permission of instructor. Spring term annually.  4 credit hours

COMM-4910 EMAC Capstone Design
EMAC Capstone Design is a two-semester sequence offered in fall and spring and is required for graduating seniors majoring in EMAC. Through a series of production and writing assignments, breakout seminars, group critiques, and public exhibition, the goal is to develop a work-in-progress in the fall semester and a final version in the spring semester of the capstone project and senior thesis paper. Both Arts and Communications sections are taught by faculty from the Arts and LL&C Departments. (This course is cross listed with ARTS-4910. Students cannot receive credit for both this course and ARTS-4910.) Fall and spring, terms annually  2 credit hours

COMM-4940 Communication Studies
Readings and projects adapted to the needs of individual students. 1 to 6 credit hours

COMM-4960 Topics in Communication
Experimental courses tried out in one or two terms.  4 credit hours
COMM-6110 Writing and Editing
An advanced writing course designed to improve the student’s facility in writing and adapting material and style to the requirements of publishing technical and professional documents. Students write and assemble their own materials and edit the writing of others. Prerequisite: undergraduate technical writing or advanced composition course or permission of instructor. Fall term annually. 3 credit hours

COMM-6240 Rhetorical Theory I
Introduces classical rhetoric and emphasizes the use of language as a means of winning the assent, sympathy, or cooperation of an audience. It examines the rhetorical theories of figures such as Gorgias, Isocrates, Plato, Aristotle, Cicero, Quintilian, and Saint Augustine. Spring term annually. 3 credit hours

COMM-6250 Rhetorical Theory II
An introduction to modern rhetoric, with an emphasis upon the use of language as a means of generating knowledge and understanding and establishing and maintaining human communities. A study of the rhetorical theories of figures such as Francis Bacon, George Campbell, Richard Whately, Kenneth Burke, C. Perelman, L. Olbrechts-Tyteca, and Michel Foucault. Fall term annually. 3 credit hours

COMM-6280 Rhetorical Analysis
The application of rhetorical concepts in the analysis and appraisal of discourse. Students pursue projects under the direction of the instructor; weekly seminar meetings are devoted principally to discussions of ongoing projects. Prerequisite: COMM-6240. Offered on availability of instructor. 3 credit hours

COMM-6310 Seminar in Interpersonal Communication
This graduate seminar introduces major organizing concepts in the social scientific study of interpersonal communication. Five general theoretical perspectives are reviewed: symbolic interactionism, social exchange theory, psychodynamic theory, social biology, and systems theory. Each perspective attributes different powers to actors and envisions human motivation quite differently. Each has also had major impact on popular and scholarly thought. Spring term alternate years. 3 credit hours

COMM-6340 Techniques for Verbal Analysis
This course introduces students to techniques for seeing the underlying patterns in verbal data, including conversations, texts, interviews, and protocols. Topics include: conversation analysis; content analysis; activity analysis; narrative analysis; protocol analysis; theme analysis; and discourse analysis. Students will have a chance to read a range of studies, discuss issues relevant to research in the field, practice analytic techniques, and conduct preliminary field research. Spring term alternate years. 3 credit hours

COMM-6350 Literacy: Practices of Reading and Writing
A survey of reading and writing practices. Topics include literacy in history, literacy and orality, the cognitive consequences of oral and written interaction, the social implications of oral and written interaction, and the relationships among orality, literacy, and cultural reproduction. Fall term alternate years. 3 credit hours

COMM-6360 Rhetorical Invention: A Social Perspective
This seminar explores contemporary perspectives on rhetorical invention and their implications for research and teaching in rhetoric, composition, literary studies, and inquiry in all disciplines. Social perspectives that question or complement traditional individualistic views of invention are emphasized. The relationship of rhetorical invention to creativity and to invention in its generic sense is also explored. Offered on availability of instructor. 3 credit hours

COMM-6400 Publication Practicum
An advanced practicum course in the design and preparation of materials for print production. Includes typesetting, selection and uses of image-based information, type and image integration, a systematic approach to the communication design process, organization principles for hierarchy and navigation, printing and binding, as well as the management and supervision of production resources. Students cannot obtain credit for both courses. Fall term annually. 3 credit hours

COMM-6420 Foundations of Human-Computer Interaction Usability
In this course, we will consider methods for gathering users’ requirements for product functions and information, ways to test products and information for usability and suitability, and procedures for incorporating the results learned through testing. We will design and conduct usability tests on products, documents, and interfaces of interest. Cross listed with COMM-4420. Students cannot obtain credit for both courses. Additional assignments at higher level required for graduate students. Fall term annually. 3 credit hours

COMM-6480 Theory and Research in Technical Communication and Human-Computer Interaction
This seminar course examines theories that have shaped, and continue to drive, the fields of technical communication and human-computer interaction with an emphasis upon the ways each field makes new knowledge. Connections between theoretical findings, research results, and the evolution of both fields as they are practiced in industry, government, and academia are important themes. Course work includes lectures, discussions, student presentations, and written projects. Prerequisite: COMM-1510, or equivalent. Spring term annually. 3 credit hours
COMM-6510 Communication Theory
Introduces students to a range of theories from across the humanities and social sciences: theories of meaning, discourse, persuasion, interpersonal communication, and mass communication. Also introduces students to how theories are constructed and how knowledge is generated in communication studies. Fall term annually.
3 credit hours

COMM-6520 Seminar in Communication Theory
This course is based on the assumption that, because humans are symbol-using creatures, an intensive study of their use of symbols will illuminate human nature and behavior. This investigation relies on such thinkers as Aristotle, G. H. Mead, Richard McKeon, Ernst Cassirer, Ludwig Wittgenstein, and Martin Heidegger. Topics in the course usually include the relationship between symbols and thought, symbols as a vehicle of analyzing behavior, and the use of symbols to coordinate social action. Offered on availability of instructor.
3 credit hours

COMM-6530, COMM-6540 Communication Research I, II
This course is designed to give training in field and experimental research methods, especially in scientific and technological communication. The student designs and conducts preliminary research projects as time permits. A fall-spring sequence annually.
3 credit hours each

COMM-6560 Visual Design
This course introduces students to the theoretical and practical use of graphics as a form of visual communication. Discussions include such topics as visual perception, design theory, formatted text, and graphics. Students have an opportunity to put theory into practice using computer graphics software. Fall term annually.
3 credit hours

COMM-6570 Typography
Text that isn't noticed isn't read. Typography is a studio course in graphic design that teaches students the fundamentals of how to choose appropriate fonts, design with type, and integrate text with graphics in any given composition. Designing emotive, aesthetically pleasing, and persuasive typographic compositions is the focus of the course. Topics will include traditions of nature writing and art, the psychological, psychoanalytical relationship between viewer, model, camera, and photographer; and the social/political effects of photography in our culture. Offered on availability of instructor.
3 credit hours

COMM-6580 Rhetoric of Nature and the Environment
A seminar course focusing on how attitudes are formed and people mobilized to action on environmental issues. Topics will include traditions of nature writing and art, the symbolic/conceptual formation of “nature” and “the environment,” and methods for analysis and development of discursive formations and persuasive strategies. Prerequisites: junior or senior status, two environmentally focused H&SS courses, and two courses in biology and/or geology, or permission of the instructor. Spring term annually.
3 credit hours

COMM-6700 Rhetoric of the Photograph
This is a theoretical course exploring three aspects of photography that have a rhetorical component. These aspects are the formal “aesthetic” elements of the photographic image; the psychological, psychoanalytical relationship between viewer, model, camera, and photographer; and the social/political effects of photography in our culture. Prerequisite: graduate standing or permission of instructor. Offered on availability of instructor.
3 credit hours

COMM-6720 Web Designing for Community Networking
This course emphasizes participatory design and the development of functional communication products for real-world clients. Students create Web-based graphic, interactive, or multimedia information resources for arts and cultural organizations, city and county government, and social-service organizations in Troy, New York. These resources may be used by the Troy Coalition for Community Networking and TroyNet. Prerequisite: at least one course in database, multimedia, or Web design. Spring term annually.
4 credit hours

COMM-6730 Computer-Mediated Communication
This seminar examines the social uses and impacts of computer-mediated communication in contexts such as education, industry, and informal social interaction. Students may examine traditionally important variables such as self-disclosure, rules, status, power, message sequencing, etc., as well as processes such as reality construction, learning, decision making, and group development. The course introduces analytic procedures that are as useful for spoken or written discourse as for computer-mediated discourse. Fall term alternate years.
3 credit hours

COMM-6740 Hypermedia Design and Development
This seminar course will investigate issues in hypermedia design and development. Class discussions will include topics such as designing the structure of a hypermedia program and designing the user interface. Students will have an opportunity to put theory into practice by designing and developing an interactive program. Prerequisite: COMM-
COMM-6750 Communication Design for the World Wide Web
This course introduces hypermedia interface design and communication issues involved in designing interactive programs for the World Wide Web. Students will design and develop an interactive Web site or experience and explore related rhetorical, social, cultural, and legal issues. Prerequisite: 1) completion of Web development or hypermedia development course and 2) knowledge of basics of Web or hypermedia development, or 3) permission of the instructor. Fall term annually. 3 credit hours

COMM-6760 Electronic Coaching Systems
This course is based on theoretical work in cognition and motor behavior and on applied research in computing, sports, and arts. This course analyzes how designers think about human performance systems. Support systems analyzed include online tutorials, wizards, agents, and Web-based systems. Prerequisite: COMM-4750 or another LL&C 4000-level graphics or document design course, or graduate standing. Spring term annually. 3 credit hours

COMM-6770 - User-Centered Design
Explore how users get involved in design: as specifiers of requirements, as evaluators, as sounding boards, and as collaborators. We will gather requirements, design to meet those requirements, and evaluate our success. Cross-listed with COMM-4770; students taking COMM-6770 will be assigned an additional project. Students cannot obtain credit for both courses. Prerequisites: COMM-4420 or permission of instructor. Spring term annually. 3 credit hours

COMM-6780 Hypermedia Art and Fiction: Theory and Design
This course is a seminar for students with some experience designing interactive multimedia computer programs (or Web sites). The seminar will explore new directions in interactive electronic art, in particular, audiovisual artworks, and hypertext fiction. Students will evaluate how interactive electronic media can be used for creative expression and present their findings in oral presentations, written reports and electronic media. Cross listed with COMM-4780. Prerequisite: previous experience as per above. 3 credit hours

COMM-6800 Media and Memory
Stories of the past are always told in some specific present, with emphases and interests grounded in that present. Collective memory is thus reshaped continuously as people fashion social realities that conform to their values and beliefs. This course focuses on the rhetorical formation of collective pasts, emphasizing the role of communication media in the process. (Cross-listed with COMM-4800. Students cannot obtain credit for both courses.) Prerequisites: one WRIT course and one COMM course. Spring term annually. 3 credit hours

COMM-6810 Studio Design in Human-Computer Interaction
In this course, students work on collaborative projects to design innovative human-computer interactions (HCIs) aimed at transforming the way people do things in their everyday lives at work, in the home, and at play. Students work with activity analysis to observe and analyze everyday practices, with object-oriented modeling to represent and transform those practices, and with UI prototyping for selected implementation. The course serves as the capstone in the HCI M.S. Certificate but is open to any student seeking an opportunity to engage in an extended design studio leading to an HCI design. Spring term annually. 3 credit hours

COMM-6940 Communication Studies
Readings and projects adapted to the needs of individual students. 1 to 6 credit hours

COMM-6960 Topics in Communication
Experimental courses tried out in one or two terms. 3 credit hours

COMM-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

COMM-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

CSCI Computer Science (SOS)

CSCI-1010 Introduction to Computer Programming
Computer programming is a way of thinking. A successful programmer needs to take a word problem, generate a pseudocode algorithm, and convert it to the syntax of a specific programming language. This course is an alternative to CSCI-1100 and is intended for students who want an introduction to this programming process but do not intend to do further course work in programming or com-
puter science. Emphasis will be on the generation of the algorithms. Rather than using the complex syntax of a production language such as C or C++, this course will use Visual Basic. This allows us to concentrate on the fundamentals and not get sidetracked by language complexity. It also affords students a tool for creating useful personal applications or prototypes in the future. (Students cannot get credit for this course if they have already taken any other CSCI course.) Spring term annually. 4 credit hours

CSCI-1100 Computer Science I
An introduction to algorithm design and analysis, programming, and the use of the World Wide Web for information dissemination and retrieval. Additional topics include basic computer organization; internal representation of scalar and array data; use of top-down design and sub-programs to tackle complex problems; abstract data types. Enrichment material as time allows. Interdisciplinary case studies, numerical and nonnumerical applications. Prerequisites: none. Students who have passed CSCI-1200 cannot register for this course. Fall and spring terms annually. 4 credit hours

CSCI-1190 Beginning C Programming for Engineers
This course will teach elementary programming concepts using the C language for engineering students with little or no prior programming experience. Students cannot get credit for this course and any other Computer Science course. No prerequisites. Fall and spring terms annually. 1 credit hour

CSCI-1200 Computer Science II
Programming concepts: functions, parameter passing, pointers, arrays, strings, structs, classes, templates. Mathematical tools: sets, functions, and relations, O-notation, complexity of algorithms, proof by induction. Data structures and their representations: data abstraction and internal representation, sequences, trees, binary search trees, associative structures. Algorithms: searching and sorting, generic algorithms, iterative and recursive algorithms. Methods of testing correctness and measuring performance. Prerequisite: CSCI-1100 or permission of instructor. Fall and spring terms annually. 4 credit hours

CSCI-2220 Programming in Java
Introduction to programming in the Java language. Java is an object-oriented programming language widely used in developing World Wide Web applications. Topics include class declarations and definitions, graphics, threads, exceptions, and writing Web applets. Prerequisite: CSCI-1200 or equivalent. Fall and spring terms annually. 2 credit hours

CSCI-2230 Programming in Perl
Introduction to programming in the Perl language. Perl is a programming language widely used for complex shell scripts, Common GateWay Interface programs for World Wide Web pages, and rapid prototyping in more general application areas. Topics include text manipulation facilities, associative arrays, Unix system-call facilities, and application to Web and systems programming. Prerequisite: CSCI-1200 or equivalent. Fall and spring terms annually. 2 credit hours

CSCI-2300 Data Structures and Algorithms
Data structures and algorithms, and the mathematical techniques necessary to design and analyze them. Basic data structures: lists, associative structures, trees. Mathematical techniques for designing algorithms and analyzing worst-case and expected-case algorithm efficiency. Advanced data structures: balanced trees, tries, heaps, priority queues, graphs. Searching, sorting. Algorithm design techniques: dynamic programming, greedy algorithms, divide-and-conquer, backtracking. Example graph, string, geometric, and numeric algorithms. Prerequisites: CSCI-1200 and MATH-1010. Fall and spring terms annually. 4 credit hours

CSCI-2400 Models of Computation
This course introduces conceptual tools for reasoning about computational processes and the languages with which they are prescribed. It bears directly upon language translation, program verification, and computability. Topics to be covered include formal languages, finite automata, pushdown automata, nondeterminism, regular expressions, context-free grammars; parsing, compiler design basics; computability, Turing machines, Church’s thesis, unsolvability and intractability. Prerequisites: CSCI-2300 and MATH-2800. Fall and spring terms annually. 4 credit hours

CSCI-2500 Computer Organization

CSCI-4020 Computer Algorithms
Basic algorithm design strategies such as greedy, dynamic programming, backtracking, and branch-and-bound; main approaches, including exact, probabilistic, approximate, and heuristic algorithms; sequential and parallel algorithms; algorithms for networks, string matching, matrix operations, and cryptography; learning algorithms. Prerequisite: CSCI-2300. Spring term annually. 4 credit hours
CSCI-4050 Computability and Complexity
This course discusses concepts of languages defined by formal grammars, Turing machines and rewriting systems, computability, Church-Turing thesis, decidable and undecidable problems, computational complexity, polynomial reducibility, NP-completeness, and Cook’s theorem. Prerequisite: CSCI-2400. Fall term annually.

4 credit hours

CSCI-4100 Machine and Computational Learning
Introduction to the theory, algorithms, and applications of automated learning (supervised, reinforcement, and unsupervised), how much information and computation are needed to learn a task, and how to accomplish it. Emphasis will be given to unifying approaches coming from statistics, function approximation, optimization and pattern recognition. Topics include: Decision Trees, Neural Networks, RBF’s, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models. Prerequisites: familiarity with probability, linear algebra, and calculus. Offered on availability of instructor.

4 credit hours

CSCI-4150 Introduction to Artificial Intelligence
Topics and techniques of artificial intelligence using the language LISP. Topics include search, knowledge representation, expert systems, theorem proving, natural language interfaces, learning, game playing, and computer vision. Techniques include pattern matching, data-driven programming, substitution rules, frames, heuristic search, transition networks, neural networks, and evolutionary computation. Development of programming proficiency in LISP is emphasized. Prerequisite: CSCI-2300. Fall term annually.

4 credit hours

CSCI-4190 Introduction to Robotic Algorithms
An introduction to algorithms for robotic systems with a focus on motion planning, processing sensor information, world modeling, and handling uncertainty. Discusses application of techniques to mobile robotics and robotic manipulations. Emphasizes practical algorithms and implementing them in the laboratory. Prerequisites: CSCI-2300, MATH-1020, and MATH-2800. Spring term even-numbered years.

4 credit hours

CSCI-4210 Operating Systems
Discussion of various aspects of computer operating systems design and implementation. Topics include I/O programming, concurrent processes and synchronization problems, process management and scheduling of processes, virtual memory management, device management, file systems, deadlock problems, system calls, and interprocess communication. Programming projects are required. Prerequisites: CSCI-2300 and CSCI-2500. Fall and spring terms annually.

4 credit hours

CSCI-4220 Network Programming
An overview of the principles of computer networks, including a detailed look at the OSI reference model and an overview of various popular network protocol suites. Concentration on Unix interprocess communication, network programming using TCP/IP, and distributed objects using CORBA. Prerequisite: CSCI-4210. Spring term annually.

4 credit hours

CSCI-4250 Computer Architectures
Basic principles of computer design, including such topics as instruction sets, memory hierarchy, arithmetic, pipelining, vector processing, interconnection networks, and multiprocessors. The course emphasizes fundamental concepts and presents examples from existing computer systems. Prerequisites: CSCI-2500 and CSCI-2300. Fall term annually.

4 credit hours

CSCI-4260 Graph Theory
Fundamental concepts and methods of graph theory and its applications in various areas of computing and the social and natural sciences. Topics include graphs as models, representation of graphs, trees, distances, matchings, connectivity, flows in networks, graph colorings, Hamiltonian cycles, traveling salesman problem, planarity. All concepts, methods, and applications are presented through a sequence of exercises and problems, many of which are done with the help of novel software systems for combinatorial computing. (Cross listed as MATH-4150. Students cannot obtain credit for both this course and MATH-4150). Prerequisite: CSCI-2300. Spring term.

4 credit hours

CSCI-4290 Robot Motion Planning
This course is an introduction to algorithmic techniques for robot motion planning. Topics include configuration space representations, roadmap methods, cell decomposition and potential field techniques, randomized path planning, collision detection, multiple robot coordination, nonholonomic motion planning, and manipulation planning. These techniques will be motivated by applications to robot manipulators and mobile robots, assembly planning, computer-aided design, computer graphics, and molecular modeling. Prerequisites: CSCI-2300 and MATH-2010. Fall term, odd-years.

4 credit hours

CSCI-4320 Parallel Programming
Techniques and methods for parallel programming: models of parallel machines and programs, efficiency and complexity of parallel algorithms. Paradigms of parallel programming and corresponding extensions to sequential programming languages. Overview of parallel languages and coordination languages and models; programming on networks of workstations. Basic parallel algorithms: elementary computation, matrix multiplication, sorting; sample scientific application. Prerequisites: CSCI-2400 and CSCI-2500. Spring term annually.

4 credit hours
CSCI-4380 Database Systems
Discussion of the state of practice in modern database systems, with an emphasis on relational systems. Topics include database design, database system architecture, SQL, normalization techniques, storage structures, query processing, concurrency control, recovery, security, and new directions such as object-oriented and distributed database systems. Students gain hands-on experience with commercial database systems and interface building tools. Programming projects are required. Prerequisites: CSCI-2300. Fall and spring terms annually. 4 credit hours

CSCI-4390 Database Mining
This course will provide an introductory survey of the main topics in data mining and knowledge discovery in databases (KDD), including: classification, clustering, association rules, sequence mining, similarity search, deviation detection, and so on. Emphasis will be on the algorithmic and system issues in KDD, as well as on applications such as Web mining, multimedia mining, bioinformatics, geographical information systems, etc. Prerequisites: CSCI-2300 and MATH-2800. Fall term annually. 4 credit hours

CSCI-4430 Programming Languages
This course is a study of the important concepts found in current programming languages. Topics include language processing (lexical analysis, parsing, type-checking, interpretation and compilation, run-time environment), the role of abstraction (data abstraction and control abstraction), programming paradigms (procedural, functional, object-oriented, logic-oriented, generic), and formal language definition. Prerequisite: CSCI-2400. Fall and spring terms annually. 4 credit hours

CSCI-4440 Software Design and Documentation
Software system design methodology emphasizing use of object oriented modeling of application domains and of software systems, and emphasizing the roles of written and oral communication in software engineering. Project management and software testing. Individual and team projects include specification, software architecture, user interfaces, and documentation of the phases of a project. Prerequisite: CSCI-2300. Fall and spring terms annually. 4 credit hours

CSCI-4600 The Human-Computer Interface
An exploration of the languages, techniques, and mechanisms used to define and enhance communication between people and computer applications, both for input and output, in the general case and for a variety of important special domains. Use of graphics in the interface; multimedia environments; alternative I/O devices; issues in interface design. Interactive in-class exercises and activities. Substantial programming projects are assigned in a number of languages and for a variety of platforms. Students also prepare oral presentations based on material from the current scientific literature. Offered on availability of instructor. 4 credit hours

CSCI-4800 Numerical Computing
A survey of numerical methods for scientific and engineering problems. Topics include numerical solution of linear and nonlinear algebraic equations, interpolation and least squares approximations, numerical integration and differentiation, eigenvalue problems, and an introduction to the numerical solution of ordinary differential equations. Emphasis is placed on efficient computational procedures including the use of library and student written procedures using high-level software such as MATLAB. (Cross listed as MATH-4800. Students cannot obtain credit for both this course and MATH-4800). Prerequisites: CSCI-1100 and MATH-2010 or ENGR-1100. Corequisite: MATH-2400. Fall term annually. 4 credit hours

CSCI-4820 Introduction to Numerical Methods for Differential Equations
Derivation, analysis, and use of computational procedures for solving differential equations. Topics covered include ordinary differential equations (both initial value and boundary value problems) and partial differential equations. Runge-Kutta and multistep methods for initial value problems. Finite difference methods for partial differential equations including techniques for heat conduction, wave propagation, and potential problems. Basic convergence and stability theory. (Cross listed as MATH-4820. Students cannot obtain credit for both this course and MATH-4820). Prerequisite: MATH-4800 or CSCI-4800. Spring term annually. 4 credit hours

CSCI-4940 Readings in Computer Science
1 to 4 credit hours

CSCI-4960 Topics in Computer Science
1 to 4 credit hours

CSCI-6050 Computability and Complexity
This course discusses modern concepts of computability and computational complexity theories. The Church-Turing thesis; variations of Turing Machines; Algorithms; Decidability; The Halting Problem; Reducibility; The Recursion Theorem; The Concept of Information; Time and Space Complexity; Intractability; NP-completeness and Cook’s theorem. Prerequisite: CSCI-2400 or equivalent. Fall term annually. 3 credit hours

CSCI-6090 Generic Software Design
Study of the generic programming approach to design and systematic classification of software components. Techniques for achieving correctness, efficiency, and generality of algorithms, data structures, and memory management. Methods of structuring a library of generic software components for maximum usability are practiced in a significant design and implementation project. Prerequisite: CSCI-2300 or equivalent. Fall term annually. 4 credit hours
CSCI-6100 Machine and Computational Learning
Introduction to the theory, algorithms, and applications of automated learning (supervised, reinforcement, and unsupervised), how much information and computation are needed to learn a task, and how to accomplish it. Emphasis will be given to unifying approaches coming from statistics, function approximation, optimization, and pattern recognition. Topics include: Decision Trees, Neural Networks, RBF's, Bayesian Learning, PAC Learning, Support Vector Machines, Gaussian processes, Hidden Markov Models. Prerequisites: familiarity with probability, linear algebra, and calculus. Offered on availability of instructor. 3 credit hours

CSCI-6130 Distributed Operating Systems
A detailed discussion of issues in distributed operating system design and in computer security. The topics discussed include distributed algorithms, distributed deadlock detection and recovery, distributed concurrency control and synchronization, cryptography, and computer security. If both CSCI-6130 and CSCI-6140 are to be taken, CSCI-6140 should be taken first. Prerequisite: CSCI-4210 or CSCI-6140. Offered on availability of instructor. 3 credit hours

CSCI-6140 Computer Operating Systems
Topics include analysis of multiprogramming systems, virtual memory, computer system performance, and queuing theory. The course also discusses tools for synchronization of parallel programs and algorithms for mutual exclusion. Prerequisite: CSCI-4210 or permission of instructor. Fall term annually. 3 credit hours

CSCI-6210 Design and Analysis of Algorithms
Theoretical and empirical analysis of algorithms; tools for on-line monitoring of the algorithm's performance. Advanced algorithms for polynomial problems; randomized heuristic and approximate algorithms. Problems include computation in discrete mathematics, number theory, linear algebra, graph theory, numerical and symbolic computing. Prerequisite: CSCI-4210 or equivalent. Fall term annually. 3 credit hours

CSCI-6220 Parallel Algorithm Design
Models of parallel computation; deterministic and probabilistic PRAM model; P-complete problems. Techniques for designing efficient parallel algorithms. Parallel sorting prefix and suffix computation, list ranking, DAG evaluation, solving linear systems, graph and combinatorial problems. Prerequisite: CSCI-4220 or equivalent. Offered on availability of instructor. 3 credit hours

CSCI-6270 Computational Vision
Introduction to the problems and techniques of vision from a computational perspective. Discussion includes computational theories of vision and particular topics such as image formation, image processing, linear systems, Fourier transforms, mathematical morphology, edge and contour detection, shape from shading, stereo, motion, surface reconstruction, robust techniques, three-dimensional representation and reasoning, object recognition, and computational geometry. Prerequisites: CSCI-2300 or equivalent and programming experience. Fall term annually. 3 credit hours

CSCI-6280 Mobile Robotics
An in-depth study of algorithms for mobile robots focusing on motion planning, localization, mapping, navigation, sensor fusion, and robot software architectures. The unifying themes of this course are navigation in known and unknown environments and structuring software to control mobile robots. Class activities include readings from the research literature and a series of programming projects. Prerequisites: CSCI-2300, and MATH-2100 or permission of instructor. Fall term, even-numbered years. 3 credit hours

CSCI-6290 Robot Motion Planning
This course is an introduction to algorithmic techniques for robot motion planning. Topics include configuration space representations, roadmap methods, cell decomposition and potential field techniques, randomized path planning, collision detection, multiple robot coordination, nonholonomic motion planning, and manipulation planning. These techniques will be motivated by applications to robot manipulators and mobile robots, assembly planning, computer-aided design, computer graphics, and molecular modeling. Prerequisites: CSCI-2300 and MATH-2100. Fall term annually. 3 credit hours

CSCI-6320 Graphical User Interfaces
Building graphical user interfaces, or GUIs, are the norm in modern computing. Once a user interface concept is designed and tested, it must be implemented by programming teams on specific hardware platforms. How the interface is specified is a real challenge. Likewise, a number of standards and tools exist that establish the "look and feel" of the interface. Introduces the history of GUIs; shows how they can be specified; presents the concept of event-driven programming upon which they are based, and discusses their current status, and compares today's standards such as Macintosh, Motif, and MS Windows. It also predicts the future based on current computer capabilities and interface trends. Prerequisite: CISH-6330 or user interface design experience. Fall term annually. 3 credit hours

CSCI-6360 Parallel Computing
A survey of fundamental issues in design of efficient programs for parallel computers. The topics discussed include models of parallel machines and programs, efficiency of parallel algorithms, programming styles for shared memory, message passing, data parallelism, and using MPI in scientific parallel programs. Parallel programming project required. Prerequisite: CSCI-4210 or equivalent. Offered on availability of instructor. 3 credit hours
CSCI-6390 Database Mining
This course will provide an introductory survey of the main topics in data mining and knowledge discovery in databases (KDD), including: classification, clustering, association rules, sequence mining, similarity search, deviation detection, and so on. Emphasis will be on the algorithmic and system issues in KDD, as well as on applications such as Web mining, multimedia mining, bioinformatics, geographical information systems, etc. Prerequisites: CSCI-2300 Data Structures and Algorithms and MATH-2800 Discrete Structures. Fall term annually. 3 credit hours

CSCI-6460 Advanced Database Management Topics
This course is a continuation of CSCI-4380 and presents a more theoretical approach to logical and physical database design. It covers such topics as algorithms for logical database design, primary and secondary indexing techniques, query processing and query optimization, and database security. Problems of interfacing a database system with an operating system and some of the issues in implementing distributed database systems are also discussed. Much of the material comes from recent research papers. A term paper may be required. Prerequisite: CSCI-4380. Offered on availability of instructor. 3 credit hours

CSCI-6470 Database Systems for Engineering Applications
A survey of traditional database systems is followed by an examination of differences between applications of those systems and engineering applications. Database systems for engineering applications are described including the concepts of long transactions, version control, object-oriented support, and concurrent engineering. Prerequisite: CSCI-4380 or equivalent or permission of instructor. Offered on availability of instructor. 3 credit hours

CSCI-6480 Theory of Compiler Design
The use of language theory and automata theory in the design of compilers. Syntax-directed compilers. Lexical analysis and computer implementation of finite state machines. Syntax analysis, parsing versus restructuring. Top-down and bottom-up parsing algorithms. TD(k) and LR(k) grammars. The Y ounges algorithm. Syntax-directed transducers. Prerequisites: CSCI-6050 or equivalent and knowledge of PASCAL, C, or LISP. Offered on availability of instructor. 3 credit hours

CSCI-6800 Computational Linear Algebra
Gaussian elimination, special linear systems (such as positive definite, banded, or sparse), introduction to parallel computing, iterative methods for linear systems (such as conjugate gradient and preconditioning), QR factorization and least squares problems, and eigenvalue problems. (Cross listed as MATH-6860. Students cannot obtain credit for both this course and MATH-6860.) Prerequisite: MATH-4800 or permission of instructor. Fall term even-numbered years. 4 credit hours

CSCI-6820 Numerical Solution of Ordinary Differential Equations
Numerical methods and analysis for ODEs with applications from mechanics, optics, and chaotic dynamics. Numerical methods for dynamic systems include Runge-Kutta, multistep and extrapolation chaotic dynamics. Methods for parabolic problems (finite differences, method of lines, ADI, operator splitting), methods for hyperbolic problems (vector systems and characteristics, dissipation and dispersion, shocks capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods). (Cross listed as MATH-6820. Students cannot obtain credit for both this course and MATH-6820.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term odd-numbered years. 4 credit hours

CSCI-6840 Numerical Solution of Partial Differential Equations
Numerical methods and analysis for linear and nonlinear PDEs with applications from heat conduction, wave propagation, solid and fluid mechanics, and other areas. Basic concepts of stability and convergence (Lax equivalence theorem, CFL condition, energy methods). Methods for parabolic problems (finite differences, method of lines, ADI, operator splitting), methods for hyperbolic problems (vector systems and characteristics, dissipation and dispersion, shocks capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods). (Cross listed as MATH-6840. Students cannot obtain credit for both this course and MATH-6840.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term odd-numbered years. 4 credit hours

CSCI-6860 Finite Element Analysis
Galerkin’s method and extremal principles, finite element approximations (Lagrange, hierarchical and 3-D approximations, interpolation errors), mesh generation and assembly, adaptivity (h-, p-, hp-refinement). Error analysis and convergence rates. Perturbations resulting from boundary approximation, numerical integration, etc. Time dependent problems including parabolic and hyperbolic PDEs. Applications will be selected from several areas including heat conduction, wave propagation, potential theory, and solid and fluid mechanics. (Cross listed as MATH-6860. Students cannot obtain credit for both this course and MATH-6860.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term even-numbered years. 4 credit hours

CSCI-6900 Computer Science Seminar
Presentation of current developments in computer science. Reports by students. 1 credit hour

CSCI-6940 Readings in Computer Science
1 to 3 credit hours
CSCI-6960 Topics in Computer Science  
1 to 3 credit hours

CSCI-6970 Professional Project  
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

CSCI-6980 Master’s Project  
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.

CSCI-6990 Master’s Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

CSCI-9990 Dissertation  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

Variable credit hours

DSES Decision Sciences and Engineering Systems (SOE)

DSES-2010 Statistics for Management  
Descriptive statistics, probability and random variables, point and interval estimation, hypothesis testing, sample size determination, contingency table analysis, basic experimental design and analysis of variance, simple linear regression. Use of statistical software on business datasets. Students cannot obtain credit for both this course and ENGR-2600. Prerequisite: MATH-1010. Fall term annually.  
4 credit hours

DSES-2200 Production and Operations Management for Industrial Engineers  
The analysis and design of production systems in manufacturing and service industries. Topics include forecasting, scheduling, inventory systems, total quality management, work load balancing, and capacity planning. Microcomputer software is used extensively. Students cannot obtain credit for both this course and DSES-2210. Prerequisite: MATH-1020 or equivalent. Spring term annually.  
3 credit hours

DSES-2210 Production and Operations Management and Cost Accounting  
The design and analysis of production and service systems. Topics include forecasting, scheduling, inventory systems, total quality management, line balancing, and capacity planning. Introduction to cost accounting. Use of analytic techniques in accounting-based decision making. Formulation and solution of POM models practiced on computers. Students cannot obtain credit for both this course and ENGR-4700 or DSES-2200. Prerequisites: MATH-1020 or equivalent. Spring term annually.  
4 credit hours

DSES-2940 Readings in DSES  
1 to 4 credit hours

DSES-2960 Topics in DSES  
4 credit hours

DSES-4140 Statistical Analysis  
Review of simple and multiple regression, selection procedures, regression diagnostics, residual analysis, stepwise regression, analysis of variance, design of experiments including factorial experiments, analysis of ordinal data and nonparametric inference, basic time series models. Extensive use of statistical software. Emphasis on statistical applications to industrial engineering. Prerequisites: ENGR-2600 and knowledge of calculus. Fall term annually.  
4 credit hours

DSES-4200 Design and Analysis of Work Systems  
Analysis and design of work and workplace. Topics covered include human-machine systems, ergonomics, work measurement systems, methods and standards, process design,
DSES-4230 Quality Control
The statistical approach to manufacturing quality control is emphasized. Consideration is given to the managerial implications and responsibilities in implementing the statistical approach. Topical coverage includes construction and interpretation of various control charts; special control charts (e.g., CUSUM, EWMA); graphical methods; specifications, tolerance limits, process capability indices; acceptance sampling; discussion of experimental design; and Taguchi methods of quality improvement. Prerequisites: DSES-4140 or DSES-4760 (MATP-4620). Spring term annually. 3 credit hours

DSES-4240 Engineering Project Management
Planning, controlling, and evaluating engineering projects. Use of network analysis techniques, PERT/CPM, budget control, time/cost tradeoff, time estimation, resource allocation, and resource leveling. Extensions include probabilistic models, multiple resource models, project organization, risk analysis, technical forecasting, and network theory. Students cannot obtain credit for both this course and ENGR-4750. Fall term annually. 3 credit hours

DSES-4250 Facilities Design and Industrial Logistics
An in-depth study of the major design issues in location and physical configuration of production and service facilities. The course emphasizes the use of mathematical models, computer modeling, and quantitative analysis as aids to the design process. Topics include plant layout and location, material handling, material flow analysis, and distribution systems. Major course concepts are developed through case studies and projects. Prerequisites: DSES-2200 or equivalent, DSES-4140 or equivalent, and DSES-4640 or DSES-4770 (MATP-4700) or equivalent. Spring term annually. 3 credit hours

DSES-4260 Industrial Safety and Hygiene
Survey of procedures and practices in industrial safety and hygiene including government regulation (OSHA), life safety, electrical safety, air contamination, noise, radiation, ventilation, illumination, toxicology, and safety engineering organization. Contemporary topics (asbestos, PCBs, AIDS) are also covered. Fall term annually. 3 credit hours

DSES-4270 Industrial and Management Engineering Design
This course provides a capstone and professional experience. Student teams work on independent projects in any field of industrial and management engineering approved by a faculty adviser. Typically, projects involve a manufacturing and service sector client who provides the student with an opportunity to gain an actual industrial experience. Memos, progress reports, and a final written and oral report are submitted to the project adviser and client. This course is a writing-intensive course. Prerequisite: senior standing. Fall and spring terms annually. 3 credit hours

DSES-4280 Decision Focused Systems Engineering
The objective of this course is to introduce students to systems engineering, especially from a decision-focused perspective. System concepts, methodologies, models and analysis are covered in relation to a system's design, development, test, evaluation, and operation. Decisions concerning a system's reliability, maintainability, usability, disposability, and affordability are systematically considered. A range of systems, including service systems, is also considered. Spring annually. Pre- or co-requisite: ENGR-2600. 3 credit hours

DSES-4470 Corporate Strategic Planning and Modeling
The integration of quantitative modeling concepts from management science, statistics, and industrial engineering as applied to strategic planning and corporate modeling. Emphasis on analytical application utilizing personal computers. Individual and group projects are utilized to provide experience in developing and managing complex planning and modeling projects. Prerequisites: DSES-4140 or equivalent and DSES-4650. Spring term annually. 3 credit hours

DSES-4510 Information Systems I
This course surveys information-systems technology for the management of corporate information as a resource. Topics include elements of system design life cycle, database concepts, and Internet processing. Managerial and technical dimensions of information systems are blended in a framework of MIS. Projects are required. Prerequisite: CSCI-1100 or equivalent. Spring term annually. 3 credit hours

DSES-4520 Information Systems II: System Analysis and Database Design
This course reviews information engineering methods and techniques in information system analysis and enterprise database design. Related topics such as telecommunications and enterprise integration and modeling are also discussed. The impact of advances in information technology is presented in the context of enterprise planning. Projects are required. Prerequisite: DSES-4510 or equivalent. Spring term annually. 3 credit hours

DSES-4530 Information Systems
This course surveys information-systems technology for the management of enterprise information as a resource. Topics include elements of system design life cycle, database concepts, and decision support. Managerial and technical dimensions of information systems are blended in a
framework for IS systems. Additional topics include telecommunications, artificial intelligence (including expert systems), and structured design. The implementation, operation, and maintenance of information systems are also discussed. Projects are required. Students cannot obtain credit for both this course and DSES-4510 or DSES-4520. Prerequisite: CSCI-1100 or equivalent. Fall term annually. 4 credit hours

DSES-4610 Operations Research Methods I
Development of basic approaches of deterministic operations research to decision problems. Focus on optimization algorithms. Introduction to linear, integer, binary integer and nonlinear programming. Genetic algorithms. Consideration of model formulation and implementation. Prerequisite: MATH-1020 or equivalent. Fall term annually. 3 credit hours

DSES-4620 Operations Research Methods II
Development of basic approaches of probabilistic operations research to decision problems. Focus on the formulation, estimation, and analysis of Markov, queuing, and discrete-event simulation models. Extensive use of computers. Prerequisite: DSES-4140 or equivalent. Spring term annually. 3 credit hours

DSES-4640 Operations Research I
Introduction to modeling and linear programming (LP) formulations of decision problems. Development of algorithms for deterministic LP models including general LP models and network models. Introduction to goal programming, dynamic programming, integer programming and nonlinear programming. Formulation and solution of LP models practiced using spreadsheet software or other LP software tools. Students cannot obtain credit for both this course and DSES-4610 or DSES-4770 or MATP-4700. Prerequisites: MATH-1020 or equivalent. Fall term annually. 4 credit hours

DSES-4650 Operations Research II
Development of basic approaches of probabilistic operations research to decision problems using Markov, queuing, and discrete-event simulation models. Focus on the formulation, estimation, and analysis of stochastic models. Extensive use of computer-based modeling. Students cannot obtain credit for both this course and DSES-4620. Prerequisite: ENGR-2600 or equivalent. Spring term annually. 4 credit hours

DSES-4750 Probability Theory and Applications
Axioms of probability, joint and conditional probability, random variables, probability density and distribution functions, expectation, functions of random variables, and limit theorems. Applications of probability to models in operations research, including queuing theory and Markov chains. (Cross listed as MATP-4600. Students cannot obtain credit for both this course and MATP-4600.) Prerequisites: MATH-1020 or equivalent or permission of instructor. Fall term annually. 4 credit hours

DSES-4760 Mathematical Statistics
A course in the theory of statistics which will provide students with a basic foundation for more specialized statistical methodology courses. Topics include sampling and sampling distributions; point estimation including method of moments, maximum likelihood estimation, uniform minimum variance estimation and properties of the associated estimators; confidence intervals; hypothesis testing including uniformly most powerful, likelihood ratio approaches, chi-square tests for goodness-of-fit and independence. The course will conclude with an introduction to linear statistical models. (Cross listed as MATP-4620. Students cannot obtain credit for both this course and MATP-4620.) Prerequisite: DSES-4750 or MATP-4600 or equivalent calculus-based course. Spring term annually. 4 credit hours

DSES-4770 Mathematical Models of Operations Research
Introduction to deterministic models of operations research including linear programming formulations, the simplex algorithm, degeneracy, geometry of convex polyhedra, duality theory, and sensitivity analysis. Special linear programming models for assignment, transportation, and network problems. Integer programming formulations along with branch and bound solution. Dynamic programming. (Cross listed as MATP-4700. Students cannot obtain credit both for this course and MATP-4700.) Prerequisites: MATH-1020 and MATH-2010 or ENGR-1100 or equivalent, or permission of instructor. Fall term annually. 4 credit hours

DSES-4780 Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcome in this course. A course project allows students to explore optimization methods and practical problems directly related to their interests. (Cross listed as MATP-4820. Students cannot obtain credit for both this course and MATP-4820.) Prerequisites: MATP-4700 or DSES-4770, and MATH-2010 or ENGR-1100, and CSCI-1100, or equivalent, or permission of instructor. Spring term annually. 4 credit hours

DSES-4810 Computational Intelligence
With ever-increasing computer power readily available, new engineering methods based on "soft computing" are emerging at a rapid rate. This course provides students a working knowledge in computational intelligence covering the basics of fuzzy logic, neural networks, genetic algo-
DSES-6000 Statistical Methods for Reliability Engineering
Statistical methods for the analysis of life-test, failure, or other durational data. Engineering applications are emphasized, but the methods are applicable to biometric, actuarial, and social science durational data. Included are basic reliability concepts and definitions; statistical life and failure distributions such as the exponential, gamma, Weibull, normal, lognormal, and extreme value; probability and hazard plotting techniques; maximum likelihood and other estimation methods. Prerequisites: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110. Spring term annually. 3 credit hours

DSES-6100 Time Series Analysis
Study of time series data for both description and prediction. Main emphasis on the classical Box-Jenkins approach to model identification, estimation, and diagnosis. Includes an introduction to spectral analysis. Applications to real data series, including forecasting problems and empirical comparison of alternative approaches. Use of computer packages for time series analysis. Prerequisite: DSES-4760 (MATP-4620) or equivalent. Spring term odd-numbered years. 3 credit hours

DSES-6090 Decision Analysis
Normative and behavioral views are taken of decision making under uncertainty. This includes a discussion of utility theory and the general problem of ascertaining decision makers' preferences. Problem structuring techniques such as influence diagrams and knowledge maps are presented. Risk analysis, including risk assessment and management, is discussed. Decision analysis software is used. A class project in risk analysis is conducted. Prerequisites: DSES-6110 or equivalent and DSES-6500 or equivalent. Spring term odd-numbered years. 3 credit hours

DSES-6040 Nonparametric Methods
Distribution-free methodology, order statistics, quantiles, runs tests, rank tests, one-sample and two-sample location and scale problems, k-sample problems, goodness-of-fit tests, measures of association, asymptotic efficiencies. Nonparametric estimation. Prerequisite: DSES-4760 (MATP-4620) or DSES-6110, or equivalent. Offered on sufficient demand. 3 credit hours

DSES-6050 Stochastic Processes
A foundational course to introduce the theory of stochastic processes and how it is used to mathematically model a wide variety of empirical phenomena such as queuing systems, inventory control, telecommunications and data networks, and reliability and maintainability. Topics include review of probability, random variables, and conditional expectation; definition of various classes of stochastic processes and their properties; the homogeneous, nonhomogeneous, and compound Poisson processes; renewal processes, discrete and continuous parameter Markov chains, birth and death processes. Prerequisites: calculus, DSES-4750 (MATP-4600). Corequisite: DSES-4760 (MATP-4620). Spring term even-numbered years. 3 credit hours

DSES-6070 Applied Multivariate Analysis
Multivariate distributions; correlations, multiple and partial; estimation and testing in multivariate analysis; multivariate regression analysis including regression with two or more variables subject to error; discriminating between multivariate populations; classification problems; determining the structure of multivariate observations by principle components and factor analysis. Prerequisites: DSES-4140 or DSES-6110. Spring term annually. 3 credit hours

DSES-6060 Applied Multivariate Analysis
Sampling procedures including the following specific techniques: simple, stratified, systematic, cluster, double, and multiple sampling; estimates for totals, proportions, and variances; ratio and regression estimates; sources of error in surveys. Prerequisite: DSES-4140 or DSES-6110 or equivalent. Offered on sufficient demand. 3 credit hours

DSES-6020 Design of Experiments
Methods of designing experiments so that statistical analysis of the resulting data will yield the maximum useful information. Testing of hypotheses; analysis of variance and covariance. Various designs, including the factorial and its modifications, incomplete blocks, Latin squares, and response surface designs are covered. Also discussed are optimality properties of design. Prerequisites: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Spring term annually. 3 credit hours

DSES-6030 Sampling Methods
Sampling procedures including the following specific techniques: simple, stratified, systematic, cluster, double, and multiple sampling; estimates for totals, proportions, and variances; ratio and regression estimates; sources of error in surveys. Prerequisite: DSES-4140 or DSES-6110 or equivalent. Offered on sufficient demand. 3 credit hours

DSES-60620 Design of Experiments
Methods of designing experiments so that statistical analysis of the resulting data will yield the maximum useful information. Testing of hypotheses; analysis of variance and covariance. Various designs, including the factorial and its modifications, incomplete blocks, Latin squares, and response surface designs are covered. Also discussed are optimality properties of design. Prerequisites: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Spring term annually. 3 credit hours

DSES-6010 Applied Regression Analysis
Emphasis is on empirical model building and evaluation for both multiple linear and nonlinear regression models. Topics specifically addressed are simultaneous estimation, diagnostics and remedial measures, selection procedures, locally weighted least squares classification variables, binary response variables, time series data, nonlinear estimation, software packages. Prerequisite: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110, or permission of the instructor. Fall term annually. 3 credit hours

DSES-6080 Senior Design Project
A class project in risk analysis is conducted. Prerequisites: DSES-4140 or DSES-6110. Spring term odd-numbered years. 3 credit hours

DSES-4960 Topics in DSES
1 to 6 credit hours

DSES-4940 Readings in DSES
1 to 4 credit hours

DSES-4980 Senior Design Project
1 to 4 credit hours

DSES-4970 Applied Multivariate Analysis
Multivariate distributions; correlations, multiple and partial; estimation and testing in multivariate analysis; multivariate regression analysis including regression with two or more variables subject to error; discriminating between multivariate populations; classification problems; determining the structure of multivariate observations by principle components and factor analysis. Prerequisites: DSES-4140 or DSES-6110. Spring term annually. 3 credit hours

DSES-4760 Applied Multivariate Analysis
Multivariate distributions; correlations, multiple and partial; estimation and testing in multivariate analysis; multivariate regression analysis including regression with two or more variables subject to error; discriminating between multivariate populations; classification problems; determining the structure of multivariate observations by principle components and factor analysis. Prerequisites: DSES-4140 or DSES-4760 (MATP-4620), or DSES-6110. Spring term even-numbered years. 3 credit hours

DSES-4750 (MATP-4600) or DSES-6110, or permission of the instructor. Spring term odd-numbered years.

DSES-4760 (MATP-4620)

DSES-6070 Statistical Methods for Reliability Engineering
Statistical methods for the analysis of life-test, failure, or other durational data. Engineering applications are emphasized, but the methods are applicable to biometric, actuarial, and social science durational data. Included are basic reliability concepts and definitions; statistical life and failure distributions such as the exponential, gamma, Weibull, normal, lognormal, and extreme value; probability and hazard plotting techniques; maximum likelihood and other estimation methods. Prerequisites: DSES-4140, or DSES-4760 (MATP-4620), or DSES-6110. Spring term odd-numbered years. 3 credit hours
DSES-6110 Introduction to Applied Statistics
A graduate course in basic statistics. Stresses application to common tasks such as summarizing large databases, making quick estimates, establishing relationships among variables, forecasting, and evaluating alternatives. Topics include probability, common discrete and continuous distributions, sampling, confidence intervals, hypothesis tests, contingency tables, statistical process control, multiple regression analysis. Extensive use of computers to analyze data sets. Students cannot obtain credit for both this course and DSES-4140. Spring term annually. 3 credit hours

DSES-6130 Statistical Computing
A course on modern computational and graphical statistics. It covers topics that are currently active in real world applications including biotechnology and information technology. The topics include stochastic simulation, importance sampling, Gibbs sampling, data visualization, dimensionality reduction, model selection, data smoothing techniques, and methods for pattern recognition. Prerequisites: DSES-4140 or DSES-4760 (MATP-4620), or DSES-6110. Fall term annually. 3 credit hours

DSES-6140 Exploratory Data Analysis
Exposition of the philosophy and tools of exploratory data analysis. Tools include graphical techniques, data transformation, robust and resistant summaries, residual analysis, and resampling methods. Applications to the analysis of real data sets, stressing alternative analysis using statistical software. Prerequisites: DSES-4140 and DSES-4760 (MATP-4620) and DSES-4760 (MATP-4620) or equivalent; DSES-6100 recommended. Spring term even-numbered years. 3 credit hours

DSES-6150 Advanced Probability for Statistical Inference
Discusses advanced probability concepts and their application to statistical inference. Topics include discrete and continuous distributions, moment generating functions, random vectors and joint distributions, order statistics, bivariate normal distribution, modes of convergence, central limit theorem, goodness of fit, and simulation of random variables. Prerequisites: DSES-4750 (MATP-4600) and DSES-4760 (MATP-4620) or equivalent; DSES-6100 recommended. Spring term even-numbered years. 3 credit hours

DSES-6170 Management of Quality, Processes, and Reliability
This course provides in-depth coverage of the quality management field by covering many of the qualitative, management aspects of quality, as well as some of the traditional quantitative measurement and control techniques. The emphasis is on the application of quality principles to develop an understanding of concepts in quality and apply these concepts in problem solving situations. Six-sigma methodology is highlighted. Some coverage of international considerations, via ISO-9000, and reliability topics is given. The aim will be to show students how companies have found solutions to problems and improved their processes, products, and services using quality management concepts. Prerequisites: DSES-6110 and DSES-6230 or equivalent. (Cross listed as MGMT-6470. Students cannot obtain credit for both this course and MGMT-6470.) Fall term annually. 3 credit hours.

DSES-6180 Knowledge Discovery with Data Mining
Data mining is the computationally intelligent extraction of information from large databases. It is the process of automated presentation of patterns, rules, and functions from large data bases to make crucial business decisions. This course takes a multi-disciplinary approach to data mining and knowledge discovery involving statistics, rule and tree induction, neural networks, genetic algorithms, visualization and fuzzy logic. The course is project driven and puts a special emphasis on the use of computational intelligence for scientific data mining related to drug design and bioinformatics. Prerequisite: ENGR-2600 or equivalent introductory course in statistics. Spring term annually. 3 credit hours

DSES-6200 Models in Facilities Planning and Materials Handling
Analytical and computational modeling of industrial engineering problems in the areas of industrial and manufacturing logistics. Specific applications include facilities planning/design, materials handling equipment/systems, material storage/distribution systems, flow line scheduling and modeling. Prerequisites: DSES-4770 (MATP-4700) or DSES-4640 or equivalent, and DSES-6110 or equivalent. Fall term even-numbered years. 3 credit hours

DSES-6210 Theory of Production Scheduling
Problems of scheduling several tasks over time. Topics include measures of performance, single machine sequencing, flowshop scheduling, the job shop problem, and priority dispatching. Integer programming, dynamic programming, and heuristic approaches to various problems are also presented. Prerequisites: DSES-4770 (MATP-4700), or equivalent. Fall term odd-numbered years. 3 credit hours

DSES-6220 Concurrent Engineering
This course examines issues in concurrent engineering (CE), a product design process using extensive information and knowledge about the product’s manufacture and life cycle performance, including design for manufacturing and assembly. Spring term annually. 3 credit hours

DSES-6230 Quality Control and Reliability
This course has the same content and requirements as DSES-4230 with material added. Additional topics include basic concepts of system and component reliability; statistical distributions such as the exponential, gamma, Weibull, and lognormal, important in the description of life
and failure phenomena; and the graphical and quantitative analysis of complete and censored life-testing and failure data. Prerequisite: DSES-4140 or DSES-4760 (MATP-4620), or DSES-6110. Fall term annually. 3 credit hours

DSES-6470 Global Strategic Management of Technological Innovation
The course helps develop an understanding of and the method for managing technology as a strategic resource of the firm. In doing so, an understanding of the process, roles, and rewards of technological innovation are developed. Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering, and manufacturing are covered. Governmental, societal, and international issues are briefly covered. The course uses a variety of cases, readings, reports, and lectures. (Cross listed as MGMT-6610. Students cannot obtain credit for both this course and MGMT-6610.) Prerequisite: permission of instructor. Fall term annually. 3 credit hours

DSES-6480 Service Operations Management
This course discusses the role of services in an economy, managing services for competitive advantage, structuring the service enterprise, managing service operations, service productivity, quality, and growth. The final part concerns quantitative models with service operations. (Cross listed as MGMT-6480. Students cannot obtain credit for both this course and MGMT-6480.) Prerequisite: permission of instructor. Spring term annually. 3 credit hours

DSES-6500 Information and Decision Technologies for Industrial and Service Systems
This course emphasizes topics related to information systems and decision making including information and decision systems in organizations, database systems, knowledge systems, system analysis and design, networks and telecommunications in information systems, information systems for service delivery. Fall term annually. 3 credit hours

DSES-6520 Enterprise Database Systems
Focus on developing competence for database systems analysis, design and processing. Additional topics such as data and rules modeling, integrity, data languages, DBMS, and distributed databases are also covered. The course presents a high-level look at design and operation issues from the perspective of information systems. Projects are required. Prerequisite: DSES-6500 or permission of instructor. Spring term annually. 3 credit hours

DSES-6530 Decision Support and Expert Systems
Concepts and types of managerial decision support systems. Topics include models for decision making, applied database, and applications of artificial intelligence. Knowledge representation, knowledge acquisition, and the development of expert systems are taught through cases and a project. Use of commercially available software packages. Prerequisite: DSES-4530 or DSES-6500 or permission of instructor. Spring term annually. 3 credit hours

DSES-6550 Information Systems Analysis and Design
Methods and procedures for understanding and modeling an organization's existing and planned information processing activities (both computerized and manual) are presented and analyzed. These models are then used to develop and design new information processing systems and management information systems. The design process includes procedures for implementing systems successfully. A CASE technology is utilized in conjunction with the design process. Prerequisite: DSES-6500 or permission of instructor. Offered on sufficient demand. 3 credit hours

DSES-6560 Information Technology and Systems for Enterprise Engineering
Role of information systems in engineering; conventional information handling models in manufacturing and services, the emerging concepts and techniques of information integration for enterprise engineering, such as e-engineering, industrial exchange (B&B) and extended enterprise control using Internet technologies. A systems development framework is employed, ranging from strategic use of information systems engineering methods for planning, analysis and design. Term projects required. Fall term annually. 3 credit hours

DSES-6570 Information Technology and Systems for E-Business
E-business uses of the Internet and other new information technologies to bring about extended enterprises on a global scale. The course examines the underlying models, methods, and the techniques of E-business systems from this enterprise perspective. Web technologies, information systems engineering, and contemporary topics such as agents and scalable enterprises are covered. Laboratory assignments and term projects are required. Prerequisites: Demonstration of literacy in information technology. Spring term annually. 3 credit hours

DSES-6600 Models for Production Control and Service Logistics
This course covers deterministic and stochastic models applied in manufacturing and service organizations with special emphasis on the study of inventory control models, logistics management models, and queuing models. Analysis of these models and their application to design and planning problems in manufacturing as well as service systems is emphasized. Prerequisites: DSES-4640 or DSES-4770 (MATP-4700), and DSES-6110 (or equivalent), or permission of instructor. Spring term annually. 3 credit hours

DSES-6610 Systems Modeling in Decision Sciences
Survey of decision science methodologies in the context of technical and economic decision problems. The course seeks to develop a conceptual understanding of these methods and basic implementation skills. Students will learn how to apply decision science methods from problem recognition
and data development through problem formulation and computer solution. Prerequisite: DSES-6110 or permission of instructor. Fall term annually.  3 credit hours

**DSES-6620 Discrete-Event Simulation**
A thorough development of a simulation language is stressed in order to progress through a series of increasingly sophisticated applications of computer simulation. Projects cover a wide range of topics: production systems, inventory, finance, transportation, and public systems. The course includes model development, statistical analysis of simulation input/output data, validation planning, and managing simulation projects. Prerequisite: DSES-6110 or equivalent. Fall term annually.  3 credit hours

**DSES-6630 Continuous and Stochastic System Simulation**
Topics include design of simulation modeling using stochastic differential equations, stochastic finite element analysis, Monte Carlo simulation, gradient estimation for parametric sensitivity analysis, simulation optimization and simulation of hybrid (discrete and continuous) systems. Applications in computer science, finance, neurocomputing, biological and hydrological sciences and operations research are considered. Extensive computer-based simulation. Prerequisite: DSES-6620 or permission of instructor. Spring term annually.  3 credit hours.

**DSES-6640 Quantitative Analysis of Health Systems**
Analytical and computer-based approaches to problems involving health care organizations are presented. Topics such as productivity, improvement, reengineering, total quality management, models to improve utilization of scarce resources, and spreadsheet models are included. The course puts analytical approaches into practice through a “live case study” in cooperation with a regional health organization. Prerequisite: DSES-6610 or equivalent. Offered on sufficient demand  3 credit hours.

**DSES-6760 Combinatorial Optimization and Integer Programming**
Review of exact and heuristic methods for solving discrete problems, including the traveling salesman problem, the knapsack problem, packing and covering problems. Algorithm complexity and NP-completeness, cutting plane methods and polyhedral theory, branch and bound, simulated annealing, tabu search, Lagrangian duality. (Cross listed as MATP-6620. Students cannot obtain credit for both this course and MATP-6620.) Prerequisites: DSES-4770 (MATP-4700). Spring term even-numbered years.  4 credit hours

**DSES-6770 Linear Programming**
A unified development of linear systems and linear programming, polyhedral theory, the simplex method, interior point methods, decomposition methods for large scale linear programming problems, the ellipsoid method, column generation algorithms for stochastic programming and other problems. (Cross listed as MATP-6640. Students cannot obtain credit for both this course and MATP-6640.) Prerequisites: DSES-4770 (MATP-4700). Spring term even-numbered years.  4 credit hours

**DSES-6780 Nonlinear Programming**
Convex sets and functions, optimality conditions in nonlinear programming, Lagrangian duality, quadratic programming algorithms for nonlinear programming including Newton’s method, quasi-Newton methods, conjugate gradient methods, together with proofs of convergence. (Cross listed as MATP-6600. Students cannot obtain credit for both this course and MATP-6600.) Prerequisites: MATH-4200 or equivalent, or permission of instructor. Fall term annually.  4 credit hours

**DSES-6800 Information Technology and Decision Systems Capstone**
Integration of the knowledge and professional practice of the Master’s in IT core and concentration courses. Topics in database systems, networking, software design, human computer interaction, management of technology, and ethics are applied within a framework of global e-business strategy. The course utilizes a Team Project with a real organization to practice major IT concepts. Team members select, develop, and present a significant technology implementation project, incorporating strategy, systems development and business planning. (This course is cross listed with ITEC-6800. Students cannot obtain credit for both this course and ITEC-6800.) Spring term annually.  3 credit hours.

**DSES-6820 Queueing Systems and Applications**
A course on fundamentals of stochastic processes and queueing theory emphasizing applications. Poisson processes, renewal processes, Markov chains, general methods in the study of Markovian and non-Markovian systems, tandem queues, networks of queues, priority and bulk queues, computational methods and simulation. Focus of the course is the application of these tools in the performance evaluation and design of computer systems, communication networks, manufacturing systems, and service systems. (Cross listed as ECSE-6820. Students cannot obtain credit for both this course and ECSE-6820.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600), or equivalent. Spring term annually.  3 credit hours

**DSES-6830 Large-Scale Systems: Case Studies and Analyses**
A case-study approach introducing the systems method to analyze large-scale systems. Qualitative and quantitative study of the problems, from problem examination to problem definition, to problem solution, and to implementation. Case studies in manufacturing, transportation, community development, water resources, and criminal justice. Emphasis is on analysis of real-world problems using tech-
niques of systems engineering and operations research and considering diverse factors such as economic, technical, sociological, and environmental issues. (Cross listed as ECSE-6830. Students cannot obtain credit for both this course and ECSE-6830.) Prerequisite: ECSE-4500. Corequisite: DSES-4770 (MATP-4700) or equivalent or permission of instructor. Fall term odd-numbered years. 3 credit hours

DSES-6840 Modeling Large-Scale Systems
Applications of operations research and systems analysis techniques to mathematical modeling of complex systems, especially large-scale public systems. Discussion of model-building approaches, emphasizing the role of creativity, rationality, and mathematics. Introduction of important quantitative techniques (e.g., geometrical probability, optimization theory, and stochastic processes) and their application to modeling emergency service systems, spatial distribution of public service facilities, congestion, land-use patterns, transportation systems, demographics, and energy. (Cross listed as ECSE-6840. Students cannot obtain credit for both this course and ECSE-6840.) Prerequisites: DSES-4770 (MATP-4700) and ECSE-4500 or equivalent; DSES-6830 (ECSE-6830) desirable. Fall term annually. 3 credit hours

DSES-6860 Evaluation Methods for Decision Making
Evaluation provides structured information for policy-relevant decision making, based on a purposeful analysis of the identified measures. Topics include tests of hypotheses, randomization/control schemes, measures framework, measurement methods, and pertinent analytic techniques. Emphasis is on the application of evaluation methods (including systems engineering and operations research techniques) to issues arising in criminal justice, education, health, housing, transportation, welfare, automated information systems, and military programs. (Cross listed as ECSE-6860. Students cannot obtain credit for both this course and ECSE-6860.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600) or equivalent. Fall term odd-numbered years. 3 credit hours

DSES-6870 Introduction to Neural Networks
Neural networks are program and memory at once, useful where traditional techniques fail, i.e., for artificial speech and image recognition. Emphasis on existing and emerging engineering applications. Parallel distributed processing, Hebb's rule, Hopfield net, back-propagation algorithm, perceptrons, unsupervised learning, Kohonen self-organizing map, genetic algorithms, neocognitron, adaline. Illustrated with computer programs and lectures. Fall term odd-numbered years. 3 credit hours

DSES-6890 Multiple Criteria Decision Making
Consideration of multiple objectives under certain and uncertain conditions, the concept of the ideal, anti-ideal, and value tradeoffs, the decision-making process, measurement of attribute importance, linear multi-objective programming, goal programming, compromise programming, dealing with uncertainty. Prerequisites: DSES-4770 (MATP-4700) or equivalent, and DSES-6110 or equivalent. Spring term odd-numbered years. 3 credit hours

DSES-6900 Seminar in DSES Research
A review of active DSES doctoral research projects and activities. Discussion of the process and stages of doctoral research in DSES. Communication of scientific research results. Prerequisite: DSES doctoral student or permission of instructor. Fall term annually. 0 credit hours

DSES-6910 Advanced Seminar in DSES
A writing intensive course. Students develop research papers under the guidance of a selected faculty adviser and present research findings in class. It is anticipated that the research paper will lead to identification of the broad area of dissertation research. Prerequisite: DSES doctoral student or permission of instructor. Corequisite: Having previously passed the DSES DQE or applied to take it in the current semester. Fall term annually. 2 credit hours

DSES-6940 Readings in DSES
3 to 6 credit hours

DSES-6960 Topics in DSES
3 credit hours

DSES-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work. 1 to 4 credit hours

DSES-6980 Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser. A Master's Project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

DSES-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate
Education to be archived in a standard format in the library. Grades will then be listed as S.  

**DSES-9990 Dissertation**  
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  

**Variable credit hours**

**ECON Economics (HSSS)**

**ECON-1200 Introductory Economics**  
Every society faces the question of choosing how to use its natural and human resources to produce goods and services and how to distribute these resources among its people. This course studies how these choices are made in markets. It also explains the determinants of total output, employment, and inflation. Attention may also be given to special topics such as the environment, trade, and population. Fall and spring terms annually.  

**4 credit hours**

**ECON-2020 Intermediate Macroeconomics**  
Attention is directed primarily to variations in the aggregate volume of output, income, and employment. Cyclical fluctuations and long-term economic trends are examined and the interrelations of business and government policies are analyzed. The applicability of economic theory to the problems of business forecasting is discussed. Prerequisite: ECON-1200 or permission of instructor. Fall and spring terms annually.  

**4 credit hours**

**ECON-2940 Readings in Economics**  
Selected topics in economics designed to acquaint students with modern economic problems and analysis in special areas beyond the introductory level. Prerequisite: ECON-1200 or equivalent.  

**4 credit hours**

**ECON-2960 Topics in Economics**  
An examination of the economic considerations that influence the creation and assimilation of new products and processes, and of the impact of technological change on the structures and evolution of the American economy and environment. Topics include productivity growth, the organization and management of industrial research and development, the interaction between technological change and industrial structure, diffusion of innovations, and technological unemployment. Prerequisite: ECON-1200 or permission of instructor. Offered on availability of instructor.  

**3 credit hours**

**ECON-4120 Quantitative Analysis**  
This course builds a foundation in the mechanics and application of linear programming and introduces simulation, systems modeling, decision analysis, and dynamic programming. Topics will be presented in lecture and then applied by a weekly computer lab, discussion section, or guest lecture. Applied examples are drawn from business management, operations research, and environmental management and policy. Labs, case studies, and a semester-long project will stress the application of various software packages and modeling techniques. Prerequisite: ECON-2010 or ECON-2020, or permission of instructor. Fall term annually.  

**4 credit hours**

**ECON-4130 Money and Banking**  
Financial institutions, especially commercial banking and the Federal Reserve System, are considered from three perspectives: their monetary roles; trends in the economic, organizational, and technological aspects of their operations; and their other economic roles—a critical view. Also, the role of money in macroeconomic theory is considered along with the role of monetary policies in relation to the problems of inflation and unemployment. Prerequisite: ECON-1200 or permission of instructor. Spring term annually.  

**4 credit hours**

**ECON-4140 Structure of American Industry**  
Acquaints students with the structural characteristics and philosophical foundations of American enterprise. Several important industries are considered from the viewpoint of market structure, conduct, and performance. Such concepts as the corporation, technological competition, and private property, together with criteria for appropriate public policy toward business are examined to orient the student to contemporary American industrial activity. Prerequisite: ECON-1200 or permission of instructor. Fall term annually.  

**4 credit hours**

**ECON-4150 Economics of Government Regulation**  
Can government intervention improve the performance of private markets and if so, when and how? How is regulatory policy actually made, and what effects has it had? We apply these questions to the experience in the U.S. and elsewhere with telecommunications, electricity, transportation, financial services, job safety, and environmental regulation. Prerequisite: ECON-2010 or permission of instructor. Offered on availability of instructor.  

**3 credit hours**
ECON-4160 Public Finance
Emphasis is placed on the analysis of efficient resource use in the public sector at the federal level. Expenditure theory, tax incidence, and income distribution policies are discussed. The effects of personal income, corporation sales, payroll, and property taxes on resource allocation, equity, and growth are considered. Prerequisite: ECON-1200 or permission of instructor. Fall term annually. 4 credit hours

ECON-4180 Development of Economic Thought
A critical examination in which comparisons are made and contrasts emphasized between different schools of economic thinking such as classicism, marginalism, socialism, institutionalism, neoclassicism, and Keynesianism. Special attention is given to historical theories and attitudes of economists toward technological change and its impact on human welfare. Prerequisite: ECON-1200 or permission of instructor. Offered on availability of instructor. 3 credit hours

ECON-4190 International Economics
Principles of international specialization and exchange. Foreign trade and payment policies, as well as international institutions, are considered in relation to such issues as international investment, technology transfer, economic development, and world economic stability. Prerequisite: ECON-1200 or permission of instructor. Fall and spring term annually. 4 credit hours

ECON-4210 Cost-Benefit Analysis
Addresses the identification and measurement of the economic gains and losses to different sectors of the economy resulting from public projects and policies. Among the projects studied are those in the area of transportation, energy, environment, and urban development. Also considered is the evaluation of the effects of government on business, as for example, consumer product and workplace safety regulation. Prerequisite: ECON-2010. Spring term annually. 4 credit hours

ECON-4230 Environmental Economics
Focuses on the relationships among technology, environmental resources, and economic growth. Builds from the neoclassical model of price-driven resource allocation and competitive equilibrium. The implications for resource scarcity, environmental sustainability, and policy are developed and compared to those derived from other schools of thought. Prerequisite: ECON-1200 or permission of instructor. Spring term annually. 4 credit hours

ECON-4240 Natural Resource Economics
Addresses the allocation of natural resources through applied study of fisheries, forestry, oil, minerals, water, and biodiversity resources. Mathematical analysis will be done using Microsoft Excel with Solver. Social and policy dynamics of allocation decisions will be explored through case studies. Field trips will address ecological and physical aspects of resource management. The intent is to develop a balanced perspective and tools to address resource management decisions across their diverse economic, social, and environmental dimensions. Prerequisite: ECON-1200 or permission of instructor. Spring term annually. 4 credit hours

ECON-4250 Ecological Economics
Ecological economics is concerned with the relationship between economic systems and the biological and physical world. It recognizes that practical solutions to pressing social and environmental problems require new interdisciplinary approaches that focus on the links between economic, social, and ecological systems. This course draws on contemporary economic thought as well as evolutionary biology, ecology, and nonequilibrium systems theory. Current problems of economic growth and the prospects for continued development in a finite world are examined in the light of new findings in these fields. Prerequisites: ECON-1200, and either ECON-4230 or ECON-4240, or permission of instructor. Spring term annually. 4 credit hours

ECON-4270 Econometrics
A basic course in the theory and methods of quantitative economics; specification of mathematical models; single and simultaneous equations; least squares and other estimation methods; testing of hypotheses; identification, aggregation, time series analysis, lagged variables, etc. Application to economic problems in such areas as demand, costs, production function, technological change, innovations, etc. Prerequisites: MATH-2010 or equivalent. ECON-2010 or equivalent, or permission of instructor. Spring term annually. 4 credit hours

ECON-4900 Seminar in Economics
Discussion and analysis of selected topics in economic theory and of current economic issues. Open to seniors with permission of instructor. Spring term annually. 2 to 4 credit hours

ECON-4940 Readings in Economics
3 to 4 credit hours

ECON-4960 Topics in Economics
Selected topics in economic analysis and problems to meet the special needs of upper-division students in various curricula throughout the Institute. This allows students to pursue more in-depth work in their areas of study. Prerequisites: ECON-1200 and permission of instructor. 4 credit hours

ECON-6140 Current Problems of American Industry
An advanced analysis of current problems confronting major American industries, regulated and unregulated. Recent changes in growth patterns, market structures, and pricing policies are examined. Considerable emphasis is
placed on emerging trends in technology and public policy, which are likely to affect significantly the future of these industries. Prerequisites: ECON-2010 and ECON-4140 or permission of instructor. Fall term annually.  3 credit hours

ECON-6150 Economics of Regulation and Deregulation
Can government intervention improve the performance of private markets and if so, when and how? How is regulatory policy actually made, and what effects has it had? We apply these questions to the experience in the U.S. and elsewhere with telecommunications, electricity, transportation, financial services, job safety, health, and environmental regulation. Prerequisite: ECON-2010 or permission of instructor. Fall term annually.  3 credit hours

ECON-6160 Advanced Public Finance
Emphasis is placed on the analysis of efficient resource use in the public sector at the federal level. Expenditure theory and tax incidence are discussed. The effects of personal income, corporation, sales, payroll, and property taxes on resource allocation, equity, growth, and technological change are considered. Prerequisite: ECON-1200 or permission of instructor. Fall term annually.  3 credit hours

ECON-6210 Advanced Cost-Benefit Analysis
The techniques necessary to appraise the economic desirability and private-sector impact of various public projects and policies are studied. Concepts such as discounting, capital rationing, project selection, shadow pricing, risk assessment, unpriced goods, and economic surplus are developed. Among the topics from which illustrative case studies are drawn are urban and transport planning, energy, water resources, government regulation, and the environment. Suitable for graduate students in professional programs. Prerequisite: ECON-6490 or ECON-620. Spring term.  3 credit hours

ECON-6230 Advanced Environmental Economics
This course examines fundamentals of neoclassical microeconomics as well as other approaches to environmental economics. The main challenge in this analysis is to sort out when standard theory can be applied to environmental policy and when additional approaches are needed. The course stresses both applied microeconomic concepts of market incentives and negotiated solutions and broader policy notions such as sustainable development. Prerequisite: ECON-2010 or permission of instructor. Spring term annually.  3 credit hours

ECON-6240 Advanced Natural Resource Economics
Addresses the allocation of natural resources through applied study of fisheries, forestry, oil, minerals, water, and biodiversity resources. Mathematical analysis will be done using Microsoft Excel with Solver. Social and policy dynamics of allocation decisions will be explored through case studies. Field trips will address ecological and physical aspects of resource management. The intent is to develop a balanced perspective and tools to address resource management decisions across their diverse economic, social, and environmental dimensions. Fall term annually.  3 credit hours

ECON-6250 Advanced Ecological Economics
A multidisciplinary course that explores linkages between economic, social, ecological, biological, and physical systems. Given its multidisciplinary approach to economic analysis, the course seeks to take a fresh look at economic theory and application. Contributing disciplines include psychology, philosophy of science, biology, and ecology. Prerequisite: ECON-6230 or ECON-6240. Spring term annually.  3 credit hours

ECON-6490 Introduction to Economic Theory
The course examines the basic concepts and techniques of economic analysis and their applications to economics problems at the level of the firm, industry, and economy as a whole. Topics include theory of product and factor pricing, national income and employment theory, monetary and fiscal theories, economic growth and fluctuations. Offered on availability of instructor.  3 credit hours

ECON-6550 Advanced Microeconomic Analysis
The central propositions of contemporary economic analysis are set forth. Topics include interaction of firms and households; determination through the market of resource allocation, outputs, prices, and incomes; capital and interest; theories of general equilibrium; static and dynamic models. Prerequisite: ECON-2010 or ECON-6490 or permission of instructor. Fall term annually.  3 credit hours

ECON-6570 Econometrics
Application of statistical and mathematical techniques to selected economic problems. The formulation and interpretation of mathematical models that involve quantifiable economic relationships. The role of probability theory and statistical inference in the solution of model systems. The methods of multivariate analysis and time series analysis are examined and their use in economic research is evaluated. Prerequisites: ECON-2010, and ECON-2020 or permission of instructor. Spring term annually.  3 credit hours
ECON-6580 Topics in Applied Econometrics
Applications of advanced econometric techniques such as two- and three-stage least squares, maximum likelihood, seemingly unrelated regression, full information likelihood, distributed lags, and autocorrelation correction to a variety of business and economic problems, including the capital asset pricing model, learning curve, economies of scale, hedonic price indexes, investment, production, and limited dependent variable models. Prerequisite: ECON-6570 or permission of instructor. Spring term alternate years. 3 credit hours

ECON-6590 Advanced Macroeconomic Analysis
This course examines theory of national income determination, the role of monetary and nonmonetary factors in our economic system as described by various schools of macroeconomics. Alternative perspectives on monetary and fiscal policies are critically examined. Prerequisite: ECON-2020 or ECON-6490 or permission of instructor. Spring term annually. 3 credit hours

ECON-6600 Seminar in Ecological Economics, Values, and Policy
This seminar in the Ecological Economics, Values, and Policy Professional Masters Program surveys the theories, methods, and world views of the approaches of ecological economics and science and technology studies to social scientific and humanistic environmental inquiry. Topics include: valuation, social construction, market failure, cultural studies, externalities, environmental policy and politics, Pareto optimality, and environmental ethics and philosophy. Fall term annually. 3 credit hours

ECON-6650 Ecological Economics Values and Policy Professional Projects
This seminar focuses on the development of practical proposals for responding to environmental problems and opportunities. Research projects will include both primary data collection and the formulation of policy recommendations. Course readings will focus on case studies that involve disputes over environmental and economic issues, providing the basis for class discussion about how such disputes can be documented, analyzed, and resolved through various scientific, legal, managerial, and policy initiatives. Prerequisites: EEVP Professional Masters students or permission of instructor. Fall term annually. 3 credit hours

ECON-6940 Readings in Economics
Selected topics in economic analysis and problems to meet the special needs of graduate students in various curricula throughout the Institute. This allows students to pursue more in-depth work in their areas of study. Prerequisites: ECON-2010 and permission of instructor. 3 credit hours

ECON-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work. 3 to 9 credit hours

ECON-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Up to 30 credit hours

ECSE Electrical, Computer, and Systems Engineering (SOE)

ECSE-2010 Electric Circuits
Techniques for the analysis and simulation of linear electric circuits, and measurements of their properties. Topics include resistive and energy-storage elements, controlled sources and operational amplifiers, systematic analysis methods, AC-steady state, power and three-phase systems, magnetic coupling and transformers, transients, s-plane representation and analysis, frequency response, and Laplace transform and computer-aided methods. Prerequisites: MATH-2400 and PHYS-1200. Fall, spring, and summer terms annually. 4 credit hours, 6 contact hours

ECSE-2050 Analog Electronics
The physics and operation of semiconductor diodes, bipolar junction transistors, and field-effect transistors in elementary analog circuits. Amplifier biasing, small-signal analysis, frequency response, and noise. Feedback design, stability and oscillator circuits. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually. 4 credit hours, 6 contact hours
ECSE-2060 Digital Electronics
Analysis and design of switching-mode circuits: NMOS, CMOS, TTL, and ECL digital-logic families. Topics include: basic logic gates (voltage-transfer characteristics, noise margin, fan out, propagation delay, power dissipation), flip flops, Schmitt triggers, oscillators, timers, interface circuitry, memories, A/D and D/A converters, GaAs digital circuits. Prerequisites: ECSE-2010 and ECSE-2610. Fall and spring terms annually.
4 credit hours, 6 contact hours

ECSE-2100 Fields and Waves I
Development and application of Maxwell’s equations in free space and within materials. Introduction to vector calculus and computer-aided analysis and design methods in electromagnetics. Applications include calculation of lumped circuit elements from field theory, plane wave propagation in various materials, and reflection from boundaries. Transmission line concepts, Smith charts, and other design tools for distributed circuits. Prerequisite: ECSE-2010. Fall, spring, and summer terms annually.
4 credit hours, 6 contact hours

ECSE-2210 Microelectronics Technology
An introductory survey of microelectronics technology emphasizing physical properties of semiconductors, device and circuit fabrication, semiconductor device operation, IC layout and design, and related CAD software. Topics include semiconductor crystals; energy bands; electronics and holes; dopant impurities; fabrication and operation of diodes, bipolar junction transistors, and field-effect transistors; CMOS chip design. Prerequisite: ECSE-2010. Corequisite: ECSE-2100 or PHYS-4210. Fall and spring terms annually.
4 credit hours, 6 contact hours

ECSE-2410 Signals and Systems
4 credit hours, 6 contact hours

ECSE-2610 Computer Components and Operations
4 credit hours, 6 contact hours

ECSE-2660 Computer Architecture, Networks, and Operating Systems
Quantitative basis of modern computer architecture, processor design, memory hierarchy, and input/output methods. Layered operating system structures, process and storage management. Layered network organization, network protocols, switching, local and wide area networks. Examples from Unix and the Internet. Prerequisite: ECSE-2610. Spring term annually.
4 credit hours, 6 contact hours

ECSE-2900 ECSE Honors Seminar
Introduction to research as a professional activity in electrical, computer, and systems engineering for participants in the ECSE Honors Program. Admission to the program is by application or invitation only, made during the fall term of the sophomore year. This seminar can be taken more than once. Spring term annually.
1 credit hour, 2 contact hours

ECSE-4010 Electrical Engineering Laboratory
Electrical and electronic measurements from DC to MHz frequencies, with large and small impedance levels, involving active and passive, analog, and digital circuits. Design evaluation by testing. Prerequisites: ECSE-2050 and ECSE-2610. Corequisite: ECSE-2100.
3 credit hours, 5 contact hours

ECSE-4060 Communication Circuits
Analysis and design of communications circuits, including coupling networks, oscillators, mixers, Class B and C r-f amplifiers; Class B and D broadband amplifiers; AM and FM modulators and demodulators; AGC and AFC and FSK circuits; pulse modulation techniques; phase-locked loops. Prerequisite: ECSE-2050; ECSE-4520 desirable. Spring term.
3 credit hours

ECSE-4080 Semiconductor Power Electronics
The application of power semiconductor devices to the efficient conversion of electrical energy. Circuit analysis, signal analysis, and energy concepts are integrated to develop steady-state and dynamic models of generic power converters. Specific topics include AC/DC conversion, DC/DC conversion, DC/AC conversion, and AC/AC conversion. These generic converters are applied as controlled rectifiers, switching power supplies, motor drives, HVDC transmission, induction heating, and others. Ancillary circuits needed for the proper operation and control of power semiconductor devices are also discussed. (Cross listed as EPOW-4080. Students cannot receive credit for both this course and EPOW-4080). Prerequisite: ECSE-2050. Full term annually.
3 credit hours

ECSE-4120 Electronic Engineering Design
A capstone design experience that integrates theory, computer simulation, and experimental laboratory work. Included are the principles of reliability and optimization. Projects include the design, simulation, practical imple-
mentation, and testing of electronic circuits. This is designated as a writing-intensive course. Prerequisite: ECSE-2050. Corequisite: ECSE-2060 and ENGR-4010. Spring term annually.  

ECSE-4160 Fields and Waves II  
A continuation of ECSE-2100. Topics include solution of boundary value problems in electromagnetics using both analytic and numerical techniques. Conducting and dielectric guiding structures for waves. Radiation from simple antennas. Low frequency applications. Prerequisites: ECSE-2100, ECSE-2050, MATH-4600. Offered on sufficient demand.  

ECSE-4170 Introduction to Microwave Engineering  
Techniques used in the analysis and design of microwave systems. Topics include wave propagation in free space and in guided structures; scattering parameters; signal flow graphs and applications to microwave networks; transmission lines and impedance matching; CAD of microwave circuits; system components; system design parameters and performance calculations. Prerequisites: ECSE-2050 and ECSE-2100. Offered on sufficient demand.  

ECSE-4180 Microwave Circuit Design  
A project-oriented course on microwave amplifier design using CAD programs such as Touchstone, E-Syn, LineCal, and Microwave Spice. Each student will do four or five design projects involving narrow band and broad band small-signal amplifiers, multistage amplifiers, microwave filters, couplers, and power amplifiers. Oral presentation by each student. This is designated as a writing-intensive course. Prerequisite: ECSE-2100. Corequisite: ENGR-4010. Spring term annually.  

ECSE-4220 VLSI Design  
Introduction to VLSI design. The fabrication, device, circuit, and system aspects of VLSI design are covered in an integrated fashion. Emphasis is on integrated circuits, device design, and the electrical performance of interconnected devices. Projects will involve the use of CAD software for process simulation, electrical analysis, physical placement, and interconnect routing. This is designated as a writing-intensive course. Prerequisites: ECSE-2050 or ECSE-2060, and ECSE-2610. Corequisite: ECSE-2210 and ENGR-4010; ECSE-4220 recommended. Spring term annually.  

ECSE-4260 Physical Design in Microelectronics  
The conversion of circuit schematics to integrated-circuit chip layouts. Emphasis is on integrated circuits, device design, and the electrical performance of interconnected devices. Projects will involve the use of CAD software for process simulation, electrical analysis, physical placement, and interconnect routing. This is designated as a writing-intensive course. Prerequisites: ECSE-2050 or ECSE-2060, and ECSE-2610. Corequisite: ECSE-2210 and ENGR-4010; ECSE-4220 recommended. Spring term annually.  

ECSE-4290 Electronic Packaging  
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as MTLE-4290 and MANE-4290. Students cannot receive credit for both this course and either MTLE-4290 or MANE-4290). Prerequisite: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. Fall term annually.  

ECSE-4320 Plasma Engineering  
Introduction to plasma physics with primary emphasis on the application of plasmas for controlled thermonuclear fusion. Plasma behavior and confinement concepts are analyzed from both single-particle and conducting-fluid models. The interaction of electromagnetic waves with plasmas, plasma transport, plasma stability, and a review of major fusion-oriented devices are also presented. Prerequisite: ECSE-2100. Offered on sufficient demand.  

ECSE-4440 Control Systems Engineering  
Application of linear feedback theory to the design of large-scale, integrated control systems. Derivation of complex mathematical models of physical systems. Synthesis of appropriate control laws to provide stability of these plants. Simulation of complex control systems on digital computers. This is designated as a writing-intensive course. Prerequisite: ECSE-2410. Fall and spring terms annually.  

ECSE-4470 Applications of Linear Systems Analysis  
A course in mathematical modeling and analysis of systems. Topics may vary and include applications of differential equations, Laplace transforms, state space techniques, classical control theory, numerical methods, Fourier transforms, and z-transforms. Weekly projects involving electrical and mechanical systems are required. Oral and written project presentations are also required. GE/RPI students only. Fall term annually.  

Students cannot receive credit for both this course and MTLE-4160. Prerequisite: ECSE-2210. Fall term annually.

ECSE-4260 Physical Design in Microelectronics  
The conversion of circuit schematics to integrated-circuit chip layouts. Emphasis is on integrated circuits, device design, and the electrical performance of interconnected devices. Projects will involve the use of CAD software for process simulation, electrical analysis, physical placement, and interconnect routing. This is designated as a writing-intensive course. Prerequisites: ECSE-2050 or ECSE-2060, and ECSE-2610. Corequisite: ECSE-2210 and ENGR-4010; ECSE-4220 recommended. Spring term annually.

ECSE-4290 Electronic Packaging  
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as MTLE-4290 and MANE-4290. Students cannot receive credit for both this course and either MTLE-4290 or MANE-4290). Prerequisite: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. Fall term annually.

ECSE-4320 Plasma Engineering  
Introduction to plasma physics with primary emphasis on the application of plasmas for controlled thermonuclear fusion. Plasma behavior and confinement concepts are analyzed from both single-particle and conducting-fluid models. The interaction of electromagnetic waves with plasmas, plasma transport, plasma stability, and a review of major fusion-oriented devices are also presented. Prerequisite: ECSE-2100. Offered on sufficient demand.

ECSE-4440 Control Systems Engineering  
Application of linear feedback theory to the design of large-scale, integrated control systems. Derivation of complex mathematical models of physical systems. Synthesis of appropriate control laws to provide stability of these plants. Simulation of complex control systems on digital computers. This is designated as a writing-intensive course. Prerequisite: ECSE-2410. Fall and spring terms annually.

ECSE-4470 Applications of Linear Systems Analysis  
A course in mathematical modeling and analysis of systems. Topics may vary and include applications of differential equations, Laplace transforms, state space techniques, classical control theory, numerical methods, Fourier transforms, and z-transforms. Weekly projects involving electrical and mechanical systems are required. Oral and written project presentations are also required. GE/RPI students only. Fall term annually.
ECSE-4490 Fundamentals of Robotics
A survey of the fundamental issues necessary for the design, analysis, control, and implementation of robotic systems. The mathematical description of robot manipulators in terms of kinematics and dynamics. Hardware components of a typical robot arm. Path following, control, and sensing. Examples of several currently available manipulators. Prerequisite: ECSE-2410. Fall term annually. 3 credit hours

ECSE-4500 Probability for Engineering Applications
Axioms of probability, joint and conditional probability, random variables, probability density and distribution functions, functions of random variables, statistical averages, empirical distributions, parameter estimation, regression, tests of hypotheses, and Markov chains. Applications to engineering data such as device characteristics, failure rates, image processing and network traffic. Prerequisite: ECSE-2410. Fall, spring, and summer terms annually. 3 credit hours

ECSE-4510 Discrete Time Systems
Sampling, quantization, reconstruction of signals. Digital filters. Mathematical tools used in the modeling, analysis, and synthesis of discrete-time communication and control systems. These include discrete Fourier transform, z-transform, state-variable, and transfer-function techniques. Applications to sampled-data control and quantized-data communications systems. Prerequisite: ECSE-2410. Fall term annually. 3 credit hours

ECSE-4520 Communication Systems
An introduction to signals and noise in electrical communication systems. Spectral analysis and filtering, including random signals. Modulation theory and techniques. System performance in the presence of noise. Other topics include television and radar systems, digital communication, receiver noise, and information theory. Prerequisites: ECSE-2010 and ECSE-2410; ECSE-4500 desirable. Fall, spring, and summer terms annually. 3 credit hours

ECSE-4540 Introduction to Voice and Image Processing
An introduction to the two fields of voice and image processing, covering analytical and implementation aspects. Optical, electronic analog and digital processing techniques are covered in the imagery field, including sampling and quantization, 2-D transforms, image transmission and compression, image enhancement, sensors, and diversified applications. The voice processing portion involves speech synthesis, analysis, identification, and transmission. Physiological properties of speech, word, and speaker identification systems, digital speech transmission and compression, Vocoder, and applications. The course usually includes one field trip. Prerequisite: ECSE-4510. Spring term annually. 3 credit hours

ECSE-4560 Signal Processing Design
Supervised capstone design projects in digital signal processing. Project areas include receivers, synchronizers, parameter estimators, digital filters, voice and image processors. This is designated as a writing-intensive course. Prerequisite: ECSE-4510. Corequisite: ECSE-4520 and ENGR-4010. Spring term annually. 3 credit hours

ECSE-4630 Lasers and Optical Systems
Optical physics and applications of lasers. Design of optical systems. Topics include: wave optics and beam propagation, Gaussian beams, resonators, optical properties of atoms and laser gain media, laser amplifiers, pulsed laser systems, applications of lasers, nonlinear optics. Three lecture hours and three laboratory hours per week. (Cross listed as PHYS-4630. Students cannot receive credit for both this course and PHYS-4630). Prerequisite: PHYS-2620 recommended. Fall term odd-numbered years. 4 credit hours

ECSE-4640 Optical Communications and Integrated Optics
Phenomena, materials, and devices for optical communications and computing. Topics include: guided wave and fiber optics, integrated optics, electro-optic and nonlinear optical switching, pulse and soliton propagation, sources and detectors. Three lecture hours and three laboratory hours per week. (Cross listed as PHYS-4640. Students cannot receive credit for both this course and PHYS-4640.) Prerequisite: PHYS-2620. Fall term even-numbered years. 4 credit hours

ECSE-4670 Computer Communication Networks
Introduction to the basic concepts of computer and communication networks. In-depth presentation of the seven layers of the Open Systems Interconnection (OSI) reference model emphasizing network design. Network architectures and protocols such as the Internet, Ethernet, and Integrated Services Digital Networks are described in order to illustrate important networking concepts. Prerequisites: ECSE-2610 and combinatorial probability such as in MATH-2800, ENGR-2600 or ECSE-4500. Fall term annually. 4 credit hours

ECSE-4710 Interactive Computer-Aided Design
Development of computer-aided design techniques using computer graphics. Interactive design structures. Geometric modeling and computational geometry. Three-dimensional curve and surface geometry. Curve and surface design. Introduction to industrial interactive design systems. Extensive use of the Rensselaer Computer Graphics System. Prerequisite: CSCI-1100 or thorough knowledge of a scientific computer language, preferably C. 3 credit hours
ECSE-4720 Solid-State Physics
An introduction to theoretical and experimental solid-state physics. Wave mechanics in the perfect crystal, X-rays, electrons, and phonons. Electrical properties of metals and semiconductors. Qualitative treatment of lattice defects. (Cross listed as PHYS-4720. Students cannot receive credit for both this course and PHYS-4720.) Prerequisites: PHYS-2100 and PHYS-2510 or equivalent. Fall term annually. 4 credit hours

ECSE-4750 Computer Graphics

ECSE-4760 Computer Applications Laboratory
Experiments and lectures demonstrate the design of digital micro- and mini-computers as both decision tools and online system components. Topics include the basic operations of a minicomputer data I/O, process control, digital filter design, digital communication, and optimal control. Prerequisites: ECSE-2410 and either ECSE-4510 or ECSE-4520. Spring term annually. 3 credit hours, 5 contact hours

ECSE-4770 Computer Hardware Design
Digital design methodologies including timing chain and counter based "hardwired" microprogram design, modules, and modular design. The course bridges LSI and MSI design treating microprocessors, and I/O interfacing. Bus protocol standards, interrupts, direct memory access, priority arbitration, asynchronous timing, and overlap or double buffering. Specific examples of design include controllers for disks, cassettes, video systems, and stepping motors. Course includes a laboratory with access to LSI-11 and M6800 microprocessors. Prerequisite: ECSE-2610; ENGR-2350 desirable. Fall term annually. 3 credit hours, 5 contact hours

ECSE-4790 Microprocessor Systems
Hardware and software design of microprocessor-based digital systems. Basic concepts and operations of on-chip components as related to digital system functionality. Architectures, instruction sets, and their interface characteristics for the microprocessor families. Introduction to 32-bit machines with in-depth treatment of 16- and 8-bit machines. Emphasis on C language cross-compilers. Weekly laboratory exercises and a group design project are required. This is designated as a writing-intensive course. Prerequisite: ECSE-2610. Corequisite: ENGR-4010. Fall term annually. 3 credit hours, 6 contact hours

ECSE-4940 Independent Studies in Electrical, Computer, and Systems Engineering
Supervised reading and research. 1 to 3 credit hours

ECSE-4960 Topics in Electrical, Computer, and Systems Engineering
3 credit hours

ECSE-4980 Senior Design Project
Get information from the curriculum office. This is designated as a writing-intensive course. Corequisite: ENGR-4010. 3 credit hours

ECSE-6010 Network Theory
The analysis of active and passive linear networks, including sensitivity, topological formulas, energy functions, positive real functions, and realizability conditions. The determination of input and transfer functions that approximate a prescribed response. Active circuit elements including negative converters, gyrators, and operational amplifiers. Prerequisite: ECSE-2050. Fall term alternate years. 3 credit hours

ECSE-6050 Advanced Electronic Circuits
Design and analysis of wideband amplifiers, differential amplifiers, and operational amplifiers; the characteristics of op-amps and their use as linear and nonlinear elements, including compensation techniques; regulated power supplies. Prerequisite: ECSE-2050. Fall term alternate years. 3 credit hours

ECSE-6210 Advanced Device Concepts
An introduction to emerging electronic and opto-electronics technology. Topics cover cutting edge technologies and novel device concepts, such as quantum devices, silicon-on-insulators (SOI), compound semiconductor devices and technologies, thin film transistors (TFTs), wide band gap semiconductor devices and technologies, Si-Ge devices, solar cells, photodetectors, semiconductor lasers, opto-electronic ICs, optical interconnects and display technologies. Prerequisite: ECSE-2210 or equivalent. Fall term annually. 3 credit hours

ECSE-6230 Semiconductor Devices and Models I
The physical operation of modern semiconductor devices and the determination of their internal parameters. Devices include diodes, unipolar and bipolar transistors, and metal-oxide-semiconductor devices. Emphasis is placed on the fundamental mechanisms that contribute to device performance. The interrelationship between device parameters and circuit performance is stressed. Prerequisite: ECSE-2210 or equivalent. Fall term annually. 3 credit hours

ECSE-6240 VLSI Fabrication Technology
Fabrication technology for silicon and gallium arsenide integrated circuits with emphasis on sub-micron structures. Topics include epitaxy, diffusion, binary and ternary phase diagrams, grown and deposited oxides and nitrides, polysilicon and silicide technology, single- and multi-metal systems, plasma and chemical etching, ion milling photo, e-beam and
X-ray lithography. Prerequisite: ECSE-4250 or equivalent. Spring term even-numbered years. 3 credit hours

**ECSE-6250 Solid-State Microwave Devices**
Physical properties of operation, modeling, and application of selected semiconductor microwave devices. Devices considered include varactors, p-n diodes, Schottky barrier diodes, avalanche transit time devices, transferred electron devices and field effect transistors. Terminal behavior of these devices, their noise characteristics, and their use in microwave circuits. Corequisite: ECSE-6230. Offered on sufficient demand. 3 credit hours

**ECSE-6260 Semiconductor Power Devices**
Special problems of semiconductor devices operating at high voltage and high current levels. Devices include p-n diodes, p-i-n diodes, transistors, and thyristors. Topics include space charge limited current flow, microplasmas, avalanche breakdown, surface contouring, cylindrical junctions and field plates, high-level injection, emitter crowding, gain and gain-bandwidth product at high current levels, double injection, lateral thermal instability, second breakdown, triggering mechanisms, plasma propagation, switching and recovery characteristics, and device fabrication technology. Prerequisite: ECSE-6230. Spring term odd-numbered years. 3 credit hours

**ECSE-6270 Optoelectronics**
Review of Maxwell’s equations for anisotropic and nonlinear media; physical models of the dielectric constant and index of refraction. Radiative processes, fundamentals of lasers, optical detectors and noise, optical modulators, and modern research topics. Prerequisites: PHYS-6710 or equivalent, ECSE-4630 or equivalent. Offered on sufficient demand. 3 credit hours

**ECSE-6290 Semiconductor Devices and Models II**
A continuation of ECSE-6230. Physical operation of insulated-gate and heterojunction field-effect devices including short-channel and hot-carrier effects. Studies of other heterojunction devices emphasize the exploitation of particular quantum-mechanical phenomena to achieve unique device behavior. Prerequisite: ECSE-6230 or equivalent. Spring term. 3 credit hours

**ECSE-6300 Integrated Circuit Fabrication Laboratory**
Theory and practice of IC fabrication in a research laboratory environment. Test chips are fabricated and the resulting devices and circuits evaluated. Processes and fabrication equipment studied and used include oxidation/diffusion, CVD reactors, photolithography, plasma etching, vacuum evaporator, ion implantation, etc. Instruments used in process monitoring and final testing include thin film profilometer, ellipsometer, resistivity probe, scanning electron microscope, capacitance-voltage system, etc. The fundamentals of hazardous material handling and clean room procedures are studied. (Cross listed as MTLE-6300. Students cannot receive credit for both this course and MTLE-6300.) Prerequisite: ECSE-4250 or equivalent. Spring term annually. 3 credit hours

**ECSE-6310 Plasma Dynamics I**
Analysis of the dynamics of plasma behavior in terms of statistical models. Development of the Boltzmann equation, the moment equations of continuity, momentum, and energy, and their application to plasma transport processes. Fall term odd-numbered years. 3 credit hours

**ECSE-6320 Plasma Dynamics II**
Plasma kinetic theory, suitability of magnetically confined plasmas, plasma radiation, plasma turbulence. Prerequisite: ECSE-6310. Spring term even-numbered years. 3 credit hours

**ECSE-6330 Plasma Devices**
Analysis of magnetically confined high-temperature devices. Equilibrium and stability of a variety of magnetic confinement systems. Diagnostic techniques, current status of experimental results, and relationship to the development of controlled fusion. Prerequisite: ECSE-6320. Fall term on sufficient demand. 3 credit hours

**ECSE-6340 Plasma Diagnostics**
Investigation of the major diagnostic techniques used for measuring parameters in magnetically confined plasmas. Several examples of mechanical, radiation, and particle techniques are developed. Emphasis is placed on the basic principles behind each technique, the hardware necessary to perform the measurements, the space and time limitations on the technique, and its role in studying fusion-oriented plasmas. Prerequisites: ECSE-6310 and ECSE-6320. Spring term on sufficient demand. 3 credit hours

**ECSE-6400 Systems Analysis Techniques**
Methods of analysis for continuous and discrete-time linear systems. Convolution, classical solution of dynamic equations, transforms and matrices are reviewed. Emphasis is on the concept of state space. Linear spaces, concept of state, modes, controllability, observability, state transition matrix. State variable feedback, compensation, decoupling. Prerequisite: ECSE-2410 or equivalent. Fall and summer terms annually. 3 credit hours

**ECSE-6410 Robotics and Automation Systems: Rigid Body Kinematics and Dynamics**
Kinematics and dynamics of general manipulator systems. Product of exponential formula. Closed kinematics chains, parallel robot, and mobile robots. Motion and force control through feedback. Path planning. Trajectory generation. Calibration and identification. Sensor fusion. Prerequisite: ECSE-6400; ECSE-4490 is desirable. Spring term odd-numbered years. 3 credit hours
ECSE-6420 Nonlinear Control Systems

ECSE-6430 Optimization Methods
Linear programming, nonlinear programming, iterative methods, and dynamic programming are presented, especially as they relate to optimal control problems. Discrete and continuous optimal regulators are derived from dynamic programming approach, which also leads to the Hamilton-Jacobi-Bellman Equation and the Minimum Principle. Linear quadratic regulators, linear tracking problems, and output regulators are treated. Linear observer and the separation theorem are developed for feedback controller implementation. Prerequisite: ECSE-2410. Corequisite: ECSE-6400. Fall term annually. 3 credit hours

ECSE-6440 Optimal Control Theory
Optimal control is approached from the Calculus of Variations point of view. Continuous and discrete variational calculus are considered as well as the discrete and continuous minimum principle. Other topics include singular control, minimum time problems, minimum fuel problems, numerical methods for nonlinear optimal control, solutions to Riccati equations, sensitivity in optimal control, and estimators. Prerequisite: ECSE-2410. Corequisite: ECSE-6400. Spring term annually. 3 credit hours

ECSE-6460 Multivariable Control Systems
An advanced course in the synthesis and analysis of linear multivariable control systems. Topics include output feedback, reduced-order modeling and control, disturbance accommodation and counteraction, pole-zero relocation via feedback, decoupling, vector frequency domain methods, decentralized control, numerical methods for controller synthesis. Emphasis on contemporary approaches to feedback controller design and connections between time and frequency domain methods. Material based on technical journals as well as textbooks. Computer design problems are assigned. Prerequisite: ECSE-6400; ECSE-6430 and ECSE-6440 desirable. Fall term. 3 credit hours

ECSE-6480 Adaptive Systems
This course contains the fundamental theory required to design adaptive systems. Topics include parameter identification, ARMA modeling, model reference systems, model algorithmic control, self-tuning systems, and adaptive filtering. Applications to physical and physiological systems are introduced. (Cross listed as BMED-6480. Students cannot receive credit for both this course and BMED-6480.) Prerequisite: ECSE-6400 or equivalent. Spring term odd-numbered years. 3 credit hours

ECSE-6510 Introduction to Stochastic Signals and Systems
Deterministic signal representations and analysis, introduction to random processes and spectral analysis, correlation function and power spectral density of stationary processes, noise mechanisms, the Gaussian and Poisson processes. Markov processes, the analysis of linear and nonlinear systems with random inputs, stochastic signal representations, orthogonal expansions, the Karhunen-Loeve series, channel characterization, introduction to signal detection, linear mean-square filtering, the orthogonality principle, optimum Wiener and Kalman filtering, modulation theory, and systems analysis. Prerequisites: ECSE-2410 and ECSE-4500 or equivalent. Fall term annually. 3 credit hours

ECSE-6520 Detection and Estimation Theory
Classical statistical decision theory, decision criteria, binary and composite hypothesis tests. Statistical models of signals and noise. Detection of known signals in Gaussian noise. Receiver operating characteristics and error probability. Applications to radar and communications. Detection of signals with unknown or random parameters, detection of stochastic signals, nonparametric detection techniques. Statistical estimation theory, performance measures. Cramer-Rao bounds, estimation of unknown signal parameters, optimum demodulation, signal design. Prerequisites: probability theory and ECSE-6510. Spring term annually. 3 credit hours

ECSE-6530 Information Theory and Coding
Information measures, characterization of information sources, coding for discrete sources, the noiseless coding theorems, construction of Huffman codes. Discrete channel characterization, channel capacity, noisy-channel coding theorems, reliability exponents. Various error-control coding and decoding techniques, including block and convolutional codes. Introduction to waveform channels and rate distortion theory. Prerequisite: probability theory. Corequisite: ECSE-6510. Fall term annually. 3 credit hours

ECSE-6550 Stochastic Processes in Communication and Control
Review of measure and integration theory, elements of probability, random variables, conditional probability, and expectations. Stochastic processes, stationarity and ergodicity, Gaussian processes and Brownian motion, the Poisson process. Markov processes, wide-sense stationary processes, spectral representations, linear prediction and filtering. Applications to random processes and spectral analysis, correlation function and power spectral density of stationary processes, noise mechanisms, the Gaussian and Poisson processes. Markov processes, the analysis of linear and nonlinear systems with random inputs, stochastic signal representations, orthogonal expansions, the Karhunen-Loeve series, channel characterization, introduction to signal detection, linear mean-square filtering, the orthogonality principle, optimum Wiener and Kalman filtering, modulation theory, and systems analysis. Prerequisites: ECSE-2410 and ECSE-4500 or equivalent. Fall term annually. 3 credit hours
ECSE-6560 Digital Communications Engineering
The functional characterization of digital signals and transmission facilities, band-limited and duration-limited signals, modulation and demodulation techniques for digital signals, error probability, intersymbol interference and its effects, equalization and optimization of baseband binary and M-ary signaling systems, error control coding techniques, digital filtering current practices in modern design. Introduction to communication networks and switched systems, store-and-forward communication systems, broadband communication techniques, channel protocol, current developments in digital communication systems design and operation. Prerequisites: ECSE-4520, linear systems theory and transform theory. Fall term annually. 3 credit hours

ECSE-6570 Digital Signal Compression: Data Compression in Theory and Practice
Principles of efficient digital representation of analog signals and their application to images, audio, and multimedia signals. Topics include rate-distortion theory, scalar and vector quantization, trellis-coded quantization (TCQ), entropy coding, Huffman coding, arithmetic coding, bit-plane coding, set partition coding, Ziv-Lempel coding, PCM, DPCM, transform coding, subband/wavelet coding, and tree/trellis coding. Certain standard or oft-used systems, evolving or current, such as JPEG, JPEG2000, JPEG-LS, Wavelet/TCQ, EZW, SPIHT, FBI Fingerprint, and MPEG will be treated. Prerequisites: ECSE-6510, ECSE-6530. Spring term odd-numbered years. 3 credit hours

ECSE-6580 Theory of Digital Communications
Review of the discrete Gaussian noise channel and development of coding theorems. Waveform channels, orthonormal expansions of signals and Gaussian noise, the vector model of waveform channels, time-bandwidth and dimensionality, optimum receiver principles, channel capacity and reliability functions, signal design and selection. Coding for the Gaussian noise channel, theoretical performance bounds, implementation of error control coding, techniques for overall system evaluation, investigation of fundamental rate versus reliability tradeoffs. Prerequisite: ECSE-6510. Spring term annually. 3 credit hours

ECSE-6600 Internet Protocols
This course will cover concepts and protocols which enable homogeneous computer networks to work with each other, including transport (TCP, UDP), network (IP, IPng), routing (RIP, OSPF), network management (SNMP, SNMPv2, RMON), and other important protocols like ARP, ICMP, DNS, BOOTP, DHCP and HTTP. Advanced topics like Mobile IP, Real-time and reservation protocols (RTP, RSVP), IP multicast (IGMP, MBONE) and network security will also be examined. Emphasis will be on breadth of coverage, as well as hands-on programming experiences. Prerequisite: ECSE-2660. 3 credit hours

ECSE-6610 Pattern Recognition
Structure of pattern classification problems. Mathematics of statistical decision theory: random vectors, multivariate probability functions, discriminants, parametric and non-parametric techniques, Bayesian and maximum likelihood estimation, feature selection, dimensionality reduction, whitening transformations. Adaptive methods and clustering. Five programming assignments and a term paper. Prerequisite: ECSE-4500 or equivalent. Fall term annually. 3 credit hours

ECSE-6620 Digital Signal Processing
A comprehensive treatment of the theory, design, and implementation of digital signal processing structures. The sampling, quantization, and reconstruction process. Design of digital filters in both the time and frequency domains. Analysis of finite word length effects. Theory and applications of discrete Fourier transforms and the FFT algorithm. Applications from the communication, control, and radar signal processing areas. Prerequisites: ECSE-4500, ECSE-4510. Fall term annually. 3 credit hours

ECSE-6630 Digital Image and Video Processing
Theory of multidimensional signal processing and its application to digital image and video processing. The first half will cover signals and systems, Fourier transform, z-transform, discrete Fourier transform, FIR and IIR filters and their design. The emphasis will be on the unexpected and important differences from the one-dimensional case. The second half consists of applications in image and video signal processing, e.g., compression coding, noise reduction, motion estimation, deblurring, and restoration. Prerequisites: ECSE-6510, ECSE-6620. Spring term annually. 3 credit hours

ECSE-6640 Digital Picture Processing
Pictures and their computer representation. Image digitization, transform, and prediction methods. Image coding and image data compression. Digital enhancement techniques, histogram equalization, differencing, smoothing, and geometric corrections. Restoration and filtering. Edge detection and picture segmentation. Geometric analysis, connectedness, size, distance, directionality, and shape. Image processing languages and software. Applications from remote sensing, scene analysis, and medical-image analysis. Prerequisites: prior exposure to probability, stochastic processes, and assembler language programming is recommended but not required. Offered on sufficient demand. 3 credit hours

ECSE-6650 Computer Vision
Image formation and visual perception. Images, line structures, and line drawings. Preprocessing, boundary detection, texture, and region growing. Image representation in terms of boundaries, regions, and shape. Three-dimensional structures and their projections. Analysis, manipulation, and classification of image data. Knowledge-based
approaches to image understanding. Applications from fields of robot vision, biomedical-image analysis, and satellite and aerial image interpretation. Offered on sufficient demand.

3 credit hours

ECSE 6660 – Broadband & Optical Networking
Review of fundamental concepts and protocols of broadband and optical networking. Convergence of telephony, internet and cable networks lead to new architectural and protocol concepts. Concepts and architectures covered in this course include: high-speed switching & router-design, traffic engineering, fiber optical communications, optical networking concepts, protection/restoration/survivability, optical link layers, quality of service, Gigabit Ethernet for MANs and broadband last-mile technologies. Prerequisite: ECSE-4500, ECSE-4670. Spring term odd-numbered years.

3 credit hours

ECSE-6670 Local Computer Networks and Multiaccess Communication
Review of OSI and IEEE 802 layered network architectures. Related queuing theory including basic Markov chain theory; M/M/1 and M/G/1 queues; and reservation, polling, and token passing systems. Protocols for multiple access channels such as satellite and packet radio networks including ALOHA and carrier sensing protocols. Local area network protocols: CSMA/CD, token passing rings and buses, implicit token protocols, and protocols for fiber optic LANs. Emphasis throughout on access protocols and their analysis. Prerequisites: ECSE-4500, ECSE-4670. Spring term even-numbered years.

3 credit hours

ECSE-6680 Advanced VLSI Design
The reliable development of VLSI designs. Topics include device modeling, comparative circuit performance, design for testability, multiprocessor architectures, and memory and microprocessor design. Laboratory experiments involve the use of an ensemble of CAD tools, including SPICE, placement and routing, and high-level design descriptions. A term report and project are required. Prerequisite: ECSE-4220. Offered on availability of instructor.

3 credit hours

ECSE-6690 VLSI Design Automation
Software design aids for specifying IC design. Covers a spectrum of logic entry, simulation, placement, routing, network extraction, verification, PG tape generation, and testing. Use of a tool set for 2 micron CMOS gate array design using an industrial foundry. Designs are actually fabricated. Prerequisites: ECSE-4770, ECSE-6700. Offered on sufficient demand.

3 credit hours

ECSE-6700 Advanced Computer Hardware Design
An advanced design and laboratory course. Design methodologies include register transfer modules and firmware microprogrammed design. Advanced microprocessor topics. “Bit-slice” philosophy of design. LSI microprocessors as design elements in larger digital systems such as high-speed channels and special purpose computers. Detailed discussion of the structure of several computers at the chip and board level. Emphasis on high-speed ECL and Schottky circuits. Specification of custom IC digital systems. This is designated as a writing-intensive course. Prerequisite: ECSE-4770. Corequisite: ENGR-4010. Spring term annually.

3 credit hours

ECSE-6710 Fuzzy Sets and Expert Systems
Introduction to fuzzy set theory and fuzzy logics: basic concepts, fuzzy logics operations. Semantic manipulation applied to case studies in approximate reasoning, linguistic modeling, decision theory, and cluster analysis. Expert systems architecture and applications. Symbolic manipulation knowledge representation, control structure, and explanation capabilities. Analysis of expert systems such as MYCIN, PROSPECTOR, OPS5, DELTA. Prerequisites: expertise in a high-level programming language, some knowledge of probability. Full term annually.

3 credit hours

ECSE-6720 Neural Network Computing
The theoretical background for learning using neural networks and important issues in the applications of neural networks. Topics include perception, associative memory, multilayer networks, recurrent networks, learning and generalization capabilities, training algorithms, learning with prior knowledge, and examples in applications. Prerequisite: familiarity with probability theory, linear algebra, and FORTRAN or C programming. Offered on sufficient demand.

3 credit hours

ECSE-6730 Fault-Tolerant Digital Systems
Theory and techniques for the diagnosis of hardware faults in digital systems and the design of fault-tolerant systems. Fault detection and diagnosis in logic networks. Static and dynamic redundancy to achieve error detection and error correction. Prerequisite: ECSE-2610. Offered on sufficient demand.

3 credit hours

ECSE-6740 Introduction to Parallel Computation
Motivation for parallel processing, technological constraints, complexity, performance characterization, communications, interconnection networks, reconfiguration and fault tolerance, systolic arrays, memory systems, large-bandwidth input/output, disk arrays, online visualization, coarse and fine-grain processor design, parallel FORTRAN and C, finite-difference and finite-elements, parallel optimization and transformation algorithms, selected signal and image processing applications, selected architectures: DAP, Ncube, CM-2, and MasPar. Prerequisites: ECSE-2660 and knowledge of probability theory. Offered on sufficient demand.

3 credit hours
ECSE-6750 Finite-State Machine Theory
Topics vary from year to year and may include methods of representation for finite-state machines, state assignments, machine decomposition theory. Experiments on finite-state machines, finite-memory machines, information-lossless machines. Linear machines, probabilistic machines, cellular arrays. Prerequisite: ECSE-2610 or consent of instructor. Offered on sufficient demand. 3 credit hours

ECSE-6770 Software Engineering I
Engineering approach to the development of small and large programming projects. The life cycle steps of project planning, requirements analysis and specification, design, production, testing and maintenance of programming systems. Examples from current literature. Use of Unix workstations and a team project with object-oriented analysis are required. Prerequisites: ECSE-2660 and CSCI-2300 or equivalent. Fall term annually. 3 credit hours

ECSE-6780 Software Engineering II
Continuation of ECSE-6770. Current techniques in software engineering with topics selected from economics, reusability, reliable software, program analysis, reverse engineering, CASE tools, automatic code generation, and project management techniques. Prerequisite: ECSE-6770. Spring term. 3 credit hours

ECSE-6790 Computational Geometry
Literature survey of current research in computational geometry and theoretical computer graphics showing recent efficient algorithms useful in graphics and CAD. Algorithms such as Voronoi networks, geometric searching, convex hulls, divide and conquer in multidimensional space, repeated rotation, preprocessing scenes to draw back to front from any viewpoint, new hidden surface algorithms, halved line elimination, polyhedron intersection, and algorithms for scenes with thousands of faces are discussed. Major research paper required. Prerequisites: ECSE-4710 or ECSE-4750, and CSCI-2300 or equivalent. Offered on sufficient demand. 3 credit hours

ECSE-6800 Advanced 3-D Computer Graphics and Visualization
This course will cover 3-D graphical application programmer interfaces (APIs) and advanced rendering techniques, visualization pipelines, creating simulations, and visualization packages. Also covered will be algorithms for extracting visual information from data sets, such as determining isosurfaces, contours, and cut planes. A programming emphasis will be on object-oriented design and systems. Term project required. Prerequisites: ECSE-4750, CSCI-2300 or equivalent, some familiarity with Java/C++. Spring term. 3 credit hours

ECSE-6820 Queuing Systems and Applications
A course on fundamentals of stochastic processes and queuing theory emphasizing applications. Poisson processes, renewal processes, Markov chains, general methods in the study of Markovian and non-Markovian systems, tandem queues, networks of queues, priority and bulk queues, computational methods, and simulation. Focus of the course is the application of these tools in the performance evaluation and design of computer systems, communication networks, manufacturing systems, and service systems. (Cross listed as DSES-6820. Students cannot receive credit for both this course and DSES-6820.) Prerequisite: ECSE-4500 or DSES-4750 or MATP-4600. Spring term even-numbered years. 3 credit hours

ECSE-6830 Large-Scale Systems: Case Studies and Analyses
A case-study approach introducing the systems method to analyze large-scale systems. Qualitative and quantitative study of the problems, from problem examination, to problem definition, to problem solution, and to implementation. Case studies in manufacturing, transportation, community development, water resources, and criminal justice. Emphasis is on analysis of real-world problems, using techniques of systems engineering and operations research, and considering diverse factors such as economic, technical, sociological, and environmental issues. (Cross listed as DSES-6830. Students cannot receive credit for both this course and DSES-6830.) Prerequisite: ECSE-4500. Corequisite: MATP-4700 or DSES-4770 or equivalent, or permission of instructor. Fall term odd-numbered years. 3 credit hours

ECSE-6840 Modeling Large-Scale Systems
Applications of operations research and systems analysis techniques to mathematical modeling of complex systems, especially large-scale public systems. Discussion of model-building approaches, emphasizing the role of creativity, rationality, and mathematics. Introduction of important quantitative techniques (e.g., geometrical probability, optimization theory, and stochastic processes) and their application to modeling emergency service systems, spatial distribution of public service facilities, congestion, land-use patterns, transportation systems, demographics, and energy. (Cross listed as DSES-6840. Students cannot receive credit for both this course and DSES-6840.) Prerequisites: MATP-4700 and ECSE-4500 (or equivalent); ECSE-6830 desirable. Fall term annually. 3 credit hours
ECSE-6860 Evaluation Methods for Decision Making
Evaluation provides structured information for policy-relevant decision making based on a purposeful analysis of the identified measures. Topics include test hypotheses, randomization/control schemes, measures framework, measurement methods, and pertinent analytic techniques. Emphasis is on the application of evaluation methods (including systems engineering and operations research techniques) to issues arising in criminal justice, education, health, housing, transportation, welfare, automated information systems, and military programs. (Cross listed as DSES-6860. Students cannot receive credit for both this course and DSES-6860.) Prerequisite: ECSE-4500 or DSES-4750 (MATP-4600) or equivalent. Fall term odd-numbered years.  3 credit hours

ECSE-6860 Seminar in Electrical, Computer, and Systems Engineering  Credit hours to be arranged
ECSE-6840 Readings in Electrical, Computer, and Systems Engineering
Supervised reading and problems, by individual arrangement.  1 to 3 credit hours

ECSE-6960 Topics in Electrical, Computer, and Systems Engineering
New or special courses are presented under this listing from time to time.  3 credit hours

ECSE-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.  3 credit hours

ECSE-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  6 to 9 credit hours

Electrical, Computer and Systems Engineering at Hartford

ECSE-4730 Computer Systems Architecture
Design principles for computer systems. Number representations, hardware algorithms for computer arithmetic. Computer system organization, control structures. Memory organization, addressing schemes, memory allocation and protection cache and virtual memories. Input/output structures, channels, interfaces. Multiprogramming and introduction to multiprocessing. Prerequisite: assembler language knowledge. (Credit will not be granted to students who receive credit for CISH-4030.) Offered biannually.  3 credit hours

ECSE-5010 Instrumentation and Measurement
Complete survey of current instrumentation technology. Mathematical development of ideal first and second order instruments. Expands to cover temperature, pressure, flow, and motion measurements. Basic measurement statistical and error analysis techniques. Prerequisite: knowledge of differential equations and Fourier transforms. Offered biannually.  3 credit hours

ECSE-7010 Fiber Optics
Review of the state of the art in optical fibers, light sources, and photodetectors. Topics include: propagation, coupling, dispersion, loss and cut-off characteristics of guided wave models in optical fibers, structural and operating parameters of various types of heterostructure lasers and light-emitting diodes and quantum efficiency, response time and noise characteristics of silicon PAD and PIN diodes. Also includes applications of optical fibers in optical communications, in data processing, and in control systems. Offered biannually.  3 credit hours

ECSE-7020 Digital Control and Estimation
Computer control and estimation algorithms including deterministic and stochastic models. Markov sequence and Bayes decision rules, linear Kalman filtering, predicting and smoothing, Parameter identification, combined state and parameter estimation. Adaptive filters and on-line rapid estimation schemes, extended and nonlinear filters.  3 credit hours
Optimal digital control of deterministic and stochastic systems. Separation theorems. Prerequisite: ECSE-6400. Offered biannually.

ECSE-7040 Electromechanical Devices and Applications
Various aspects of industrial motion control systems including rotary to linear transmissions, energy conversion, actuators, sensors, analog, and digital control. Emphasizes the systems approach with interaction between components. Prerequisite: basic knowledge of linear feedback systems. Offered biannually.

ECSE-7060 Digital Modeling of Dynamic Systems

ECSE-7100 Real-Time Programming and Applications
Hardware and software characteristics of real-time systems for analysis and control. Real-time programming techniques, standard interfaces and busses, sensors, data smoothing, digital filtering, and digital control. Prerequisite: CISH-4030 (or ECSE-4730) and CSCI-4210. Offered on sufficient demand. Offered biannually.

ECSE-7120 Control Theory
Synthesis of closed loop pole-zero configuration to satisfy system specification; development of open loop compensation for a fixed plant to produce desired overall response. Offered biannually.

ECSE-7260 Computer Arithmetic and Computations
Processor architecture, data-operations unit design and hardware realization of arithmetic logical functions associated with modern digital computer systems. Machine arithmetic theories, algorithms and designs of high-speed/cost-effective fixed and floating point adder/subtracters, multipliers, and dividers. Binary and decimal computations. Microprogramming and writable-control-store applications. Prerequisite: ECSE-4730 or CISH-4010. Offered biannually.

ENGR Core Engineering (SOE)

ENGR-1010 Professional Development I
An introduction to the issues related to working in team settings. Topics explored include: communications in teams, public speaking and self-awareness, stages of group development, building a team, group decision making, and conflict resolution. The course format will include small and large group discussions, case studies, experiential exercises, and regular participation from industry guests. Offered in conjunction with ENGR-2050. Fall and spring terms annually.

ENGR-1100 Introduction to Engineering Analysis
An integrated development of linear algebra and statics emphasizing engineering applications and also incorporating computer exercises involving matrix techniques and calculations using available software packages. Fall, spring, and summer terms annually.

ENGR-1200 Engineering Graphics and CAD
An introduction to the techniques for creating solid models of engineering designs. Topics include three-dimensional modeling of parts and assemblies, visualization, orthographic and isometric free-hand sketching, and computer-generated design documentation. Fall, spring, and summer terms annually.

ENGR-1300 Introduction to Engineering Processes
The use of basic machine tools such as lathes, milling machines, drill presses, band saws, and grinders, including micrometers, vernier calipers, and other devices of use in a machine shop or laboratory. Welding techniques and tool making are also considered. Fall, spring, and summer terms annually.

ENGR-1310 Introduction to Engineering Electronics
A hands-on experience with electronic circuits and modern laboratory instrumentation. Motivates further study of engineering. The laboratory provides opportunities to build and test simple electronic circuits that illustrate basic concepts. A design project is included. Fall and spring terms annually.

ENGR-1330 Introduction to Biomedical Engineering
This is a course for first and second year engineering students which provides an overview and introduction to the field of Biomedical Engineering. It will present the many aspects of the discipline, with information about the state of the art, current practices and challenges confronting the field. Career opportunities will be identified, and the education and training needed to qualify for different jobs will be outlined. Fall term annually.
ENGR-1600 Materials Science for Engineers
Introduction to “real” (defect-containing) solids, and equilibria and kinetic processes in solids. Macroscopic properties, such as mechanical strength and electrical conductivity, are dominated by structure and bonding, and the course continuously emphasizes this connection. Each of the materials classes (metals, ceramics, semiconductors, and polymers) is discussed in detail in this context. Prerequisite: CHEM-1300 or CHEM-1100, although the former is recommended. Fall and spring terms annually.

4 credit hours, 5 contact hours

ENGR-2020 Product Design and Innovation Design Studio II
This design studio focuses on the product development process with an emphasis on problem definition and the impact that the designer has on the final outcome. Students are exposed to basic social science methods of observation and the role they can play in discovering and defining problems. Students are expected to develop a design from initial definition through actual use. Development of individual design skills in design development, presentation, and portfolio building are also emphasized. Prerequisite: ARCH-2XXX, Design Studio I, or permission of the instructor. Spring term annually.

4 credit hours

ENGR-2050 Introduction to Engineering Design
A first course in engineering design which emphasizes creativity, teamwork, communication, and work across engineering disciplines. Students are introduced to the design process through a semester-long project which provides a design-build-test experience. Oral and written communication are important elements of the course. The course meets with ENGR-1010. Prerequisites: ENGR-1100, ENGR-1200, and either ENGR-1300, ENGR-1310, or ENGR-1330. Corequisite: PHYS-1200. Fall, spring, and summer terms annually.

4 credit hours, 6 contact hours

ENGR-2090 Engineering Dynamics
An integrated development of modeling- and problem-solving techniques for particles and rigid bodies emphasizing the use of free-body diagrams, vector algebra, and computer simulation. Topics covered include the kinematics and kinetics of translational, rotational, and general plane motion, energy and momentum methods, and single degree of freedom vibrations. Prerequisites: ENGR-1100 and PHYS-1100. Corequisite: MATH-2400. Fall and spring term annually.

4 credit hours

ENGR-2250 Thermal and Fluids Engineering I
Application of control volume balances of mass, momentum, energy and entropy in systems of practical importance to all engineers. Identification of control volumes, properties of pure materials, mass and energy conservation for closed and open systems, second law of thermodynamics, Bernoulli equation, fluid statics, forces and heat transfer in external and internal flows, conduction and radiative heat transfer. Prerequisites: ENGR-1100 and PHYS-1100. Corequisite: MATH-2400. Fall, spring, and summer terms annually.

ENGR-2350 Embedded Control
Engineering laboratory introduction to the microprocessor as an embedded element of engineering systems. Students simultaneously develop the hardware and software of one or more target systems during the semester. Topics include concepts and practices of microcontroller hardware and software for command, sensing, control, and display. Specifically this includes control of dynamic systems and sensor interfaces; analog-digital conversion; parallel input/output; driver circuits, modular programming, and subsystem integration. Prerequisite: a programming language, preferably C. Fall, spring, and summer terms annually.

4 credit hours

ENGR-2530 Strength of Materials
Concept of stress and strain, generalized Hooke’s law, axial load, torsion, pure bending, transverse loading, transformation of stress and strain components in 2-D, design of beams and shafts for strength, deflection of beams, work and energy, columns. Prerequisite: ENGR-1100. Fall, spring and summer terms annually.

4 credit hours

ENGR-2600 Modeling and Analysis of Uncertainty
Appreciation and understanding of uncertainties and the conditions under which they occur, within the context of the engineering problem-solving pedagogy of measurements, models, validation, and analysis. Problems and concerns in obtaining measurements; tabular and graphical organization of data to minimize misinformation and maximize information; and development and evaluation of models. Concepts will be supported with computer demonstration. Applications to problems in engineering are emphasized. Prerequisite: MATH-1010. Fall and spring terms annually.

3 credit hours

ENGR-2710 General Manufacturing Processes
A classroom study of the basic theory and methods of traditional and nontraditional machining, metal joining, material working, and foundry processes, and the variety of functions performed by the primary machine tools employed by the modern manufacturing community. A basic first course or terminal course for all students who are interested in manufacturing processes. Fall and spring terms annually.

3 credit hours

ENGR-2830 Nuclear Phenomena for Engineering Applications
A survey of atomic and nuclear phenomena and their application in various engineering disciplines. Systematics of atoms and nuclei; nuclear reactions and their characterization; radioactive decay; fission and fusion energy release; radiation effects on materials and biological sys-
tems; radiation production, detection and protection. Applications in energy production, manufacturing, medicine, etc. Prerequisite: PHYS-1100 and CHEM-1500. Spring term annually.  
ENGR-2940 Engineering Project  1 to 3 credit hours  
ENGR-2960 Topics in Engineering  1 to 3 credit hours  
ENGR-4010 Professional Development III  
Students will study issues associated with working in teams in a modern work environment. Various styles of leadership, the definitions of power and empowerment and their applications in industry and team settings will be studied. Additionally, other topics to be explored include vision, values and attitudes, and organizational culture. The course format will include small and large group discussions, case studies, experiential exercises, and regular participation from industry guests. Offered in conjunction with senior courses.  
1 credit hour  
ENGR-4050 Modeling and Control of Dynamic Systems  
4 credit hours  
ENGR-4060 Inventor's Studio  
Students work in teams to continue design and development work on approved projects that started in other courses such as Introduction to Engineering Design. New projects can also be proposed by students. Emphasis will be on completing the design, building an improved prototype, applying for patent protection, and licensing the design. Open to undergraduate and graduate students. Oral and written presentations are required. This is designated as a writing-intensive course. Prerequisite: ENGR-2050 or permission of instructor. Fall and spring terms annually.  
3 credit hours  
ENGR-4100/ENGR-6100 Business Issues for Engineers and Scientists  
Investigates business-related considerations in successfully commercializing new technology in a new venture or within an existing enterprise: market and customer analysis, beating the competition, planning and managing for profitability, high-tech marketing and sales, and business partnerships and acquisitions. Not a general management course; focuses explicitly on what is relevant for engineers and scientists working in a commercial environment. For junior/senior undergraduate or graduate students. Fall term annually.  
3 credits undergraduate  
4 credits undergraduate  
ENGR-4300 Electronic Instrumentation  
A survey, application-oriented course for engineering and science majors. Transducers and measurement devices. DC and AC analog circuits including impedance, power, frequency response, and resonance. Diodes, transistors, and operational amplifiers. Signal conditional, noise, and shielding. Digital electronics, A/D and D/A conversion. Power supplies, rectifiers, and electromagnetic devices. Credit not allowed for ECSE majors or for students taking ECSE-2010. Prerequisite: MATH-2400 and PHYS-1200. Fall and spring terms annually.  
4 credit hours  
ENGR-4700 Introduction to Manufacturing Planning  
A survey of the basic concepts and analytical methodologies used to plan and control a manufacturing system. Topics include forecasting, production scheduling, facility layout, inventory control, and project planning. Admission by application. Restricted to juniors in engineering. Students cannot obtain credit for both this course and DSES-2210. Spring term annually.  
3 credit hours  
ENGR-4710 Advanced Manufacturing Laboratory I  
Theory and laboratory experimentation in selected modern manufacturing technologies. Topics include robotics, injection molding, computer numerically controlled (CNC) machines, metal processing systems, nondestructive testing (NDT), and industrial safety. Prerequisite: ENGR-4700 recommended. Fall term annually.  
3 credit hours, 6 contact hours  
ENGR-4720 Advanced Manufacturing Laboratory II  
Students are organized into “companies” to design, manufacture, and sell products based on the technologies of ENGR-4710. Individual projects for in-depth studies of one or more of these technologies. Additional topics include marketing and development of technical writing and oral presentation skills. Prerequisite: ENGR-4710. Spring term annually.  
3 credit hours, 6 contact hours  
ENGR-4750 Engineering Economics and Project Management  
This course deals with cost analysis in engineering decision making and the management and control of complex projects. Engineering economics topics include interest formulas and equivalence calculations, inflation, measures of investment worth, after tax analysis, depreciation accounting and replacement analyses, life-cycle costing and design economics, risk analysis and cost-benefit analysis. Engineering project management topics include methods for planning, evaluation, organization, budgeting, cost esti-
mating, scheduling, expediting, reporting, monitoring, and implementation of projects. Students cannot obtain credit for both this course and either ENGR-4760 or DSES-4240. Spring term annually. 4 credit hours

ENGR-4760 Engineering Economics
The objective is to help engineering students recognize and understand the importance of cost factors that are inherent in all engineering decisions. Development of ability to handle engineering problems that involve economic factors. The course includes economic environment, selections in present economy, value analysis, critical path economy, interest and money-time relationships, depreciation and valuation, capital financing and budgeting, basic methods for undertaking economic studies, risk, uncertainty and sensitivity, selections between alternatives, fixed, increment, and sunk costs, the effects of income taxes in economic studies, replacement studies, minimum cost formulas, economic studies of public projects, economic studies in public utilities. Effects of inflation are considered at each step. Students cannot obtain credit for both this course and ENGR-4750. Spring term annually. 3 credit hours

ENGR-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A,B,C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ENVE Environmental Engineering (SOE)

ENVE-2110 Introduction to Environmental Engineering
The application of basic principles and equations dealing with water, air, and solid and hazardous wastes; material and energy balances; and chemical and biochemical cycles. Topics include water resources, water quality and pollution, air quality and pollution, solid and hazardous wastes, and environmental legislation. Corequisite: MATH-2400. Fall term annually. 4 credit hours

ENVE-2940 Readings in Environmental Engineering 1 to 3 credit hours

ENVE-4110 Aqueous Geochemistry
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. The course covers principles of chemical equilibrium, activity models for solutes, pH as a master variable, concentration and Eh-pH diagrams, mineral solubility, aqueous complexes, ion exchange, and stable isotopes. The carbonate system, weathering reactions, and acid rain are examined in detail. Emphasis is on the chemical reactions that control surface and groundwater evolution in natural and engineered (treatment process) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance. (Cross listed as CHEM-4690 and ERTH-4690. Students cannot obtain credit for both this course and either CHEM-4690 or ERTH-4690). Prerequisite: permission of the instructor. Fall term annually. 4 credit hours

ENVE-4150, ENVE-4160 Environmental Engineering Laboratory I, II
A two-term laboratory course on experimental analysis of the operations and processes of environmental engineering. Emphasis is placed on planning of experiments, data evaluation, and report writing. Fall and spring terms annually. 2 credit hours each

ENVE-4170 Environmental Process Design I
The design of equipment, processes, and systems of interest in environmental engineering through application of scientific, technological, and economic principles. Health and safety issues are presented. Emphasis is placed on problem formulation and the conceptual, analytical, and decision aspects of open-ended design situations. The work integrates knowledge and skills gained in previous and concurrent courses. This course leads to ENVE-4180. Prerequisite: ENVE-2110 and senior standing. Fall term annually. 1 credit hour

ENVE-4180 Environmental Process Design II
Basic tenets of design are continued. Professional development topics are presented including engineering ethics, among others. Included are field inspection trips to pollution-control facilities. This is a writing-intensive course. Prerequisite: ENVE-4170. Spring term annually. 2 credit hours

ENVE-4200 Solid and Hazardous Waste Engineering
Classification and characteristics of solid and hazardous wastes; appropriate waste management systems; design of collection and transfer systems; methods of destruction and disposal, including landfills; recycle methods; and salvage and conversion operations for resource recovery. Spring term annually. 3 credit hours
ENVE-4210 Industrial Waste Treatment and Disposal
Physical, chemical, and biological characteristics of industrial wastes. Application of unit operations and processes to the treatment of waste streams. Consideration of recovery and/or recycling of useful products. Offered on availability of faculty. 3 credit hours

ENVE-4220 Environmental Law
This course provides environmental engineers, researchers, managers, public officials, and corporate executives with a firm foundation in the environmental laws and regulations with which and under which they must work. Classroom lectures and discussions generate papers on selected environmental law topics. Offered on availability of faculty. 3 credit hours

ENVE-4240 Bench Scale Design
The design and operation of different laboratory experiments to provide experience for the environmental engineer in the practical application of chemical and biological theory. Design parameters are developed via bench scale testing. Topics can include biological treatment, phytoremediation, composting of solid waste and soil columns, and microbial respirometry. Spring term annually. 3 credit hours

ENVE-4310 Applied Hydrology and Hydraulics
Physical processes governing occurrence and distribution of precipitation, infiltration, evaporation, and surface water runoff. Groundwater hydrology, mechanics of flow, and well hydraulics. Statistical hydrology, unit hydrograph theory, and watershed modeling. Floodplain hydrology and open channel hydraulics. Urban hydrology, hydraulics and design of storm sewers, and design of detention structures for flood control. Design project using the Army Corps of Engineers Hydraulic Engineering Center HEC-1 flood hydrograph package. Prerequisite: CHME-4010. Spring term annually. 3 credit hours

ENVE-4320 Environmental Chemodynamics
The movement of chemicals in air, water, and soil is presented to demonstrate the relation of physiochemical principles in the behavior of chemicals in the environment. Topics include chemical and thermal equilibrium at environmental interfaces, transport fundamentals, and the fate and transport of chemicals in various environmental compartments. Prerequisites: ENVE-2110 or CHME-2010. Corequisite: CHME-4010. Spring term annually. 3 credit hours

ENVE-4330 Atmospheric Pollution
Fundamentals of atmospheric pollution with emphasis on emissions from major sources such as combustion. Principal pollutants discussed are: particles, trace metals, sulfur, nitrogen, and carbon oxides, oxidants, and hazardous organics; as well as the thermodynamic and kinetic aspects of their formation. Role of meteorology in pollutant emission, atmospheric transport, and atmospheric chemistry, source/receptor relationships, including modeling of these relationships using one or more computer models. Some aspects of engineering control of emissions. Prerequisites: CHEM-1300 and CHME-4010. Fall term annually. 3 credit hours

ENVE-4340 Physicochemical Processes in Environmental Engineering
Physical and chemical processes governing water quality in natural and engineered systems with applications to potable water treatment. Topics include reactor dynamics, coagulation and flocculation, sedimentation, filtration, gas transfer, adsorption and ion exchange, and membrane processes. A design project for which students develop a computer model of an environmental process is required. Prerequisite: CHME-4010. Spring term annually. 3 credit hours

ENVE-4350 Biological Processes in Environmental Engineering
The study of biochemical and biological processes common to environmental engineering. Introductory physiology, biochemistry and ecology of bacteria, yeasts, fungi. Laboratory work in microbial techniques. Development of reaction rate and mass balances on biological reactors for pollution control. Topics covered include biogeochemical cycling, thermodynamics of biodegradative processes, activated sludge, trickling filters, stabilization ponds, sludge treatment and digestion, bioremediation, hazardous waste treatment, biological metal cycling and biological solid waste treatment processes. Prerequisite: ENVE-4320. Fall term annually. 4 credit hours

ENVE-4940 Studies in Environmental Engineering
1 to 4 credit hours

ENVE-4960 Topics in Environmental Engineering
1 to 4 credit hours

ENVE-4980 Senior Project
1 to 4 credit hours

ENVE-6110 Seepage, Drainage, and Groundwater
Introduction to groundwater hydrology, well hydraulics, permeability, seepage, flow nets, filter criteria, dewatering, slope stabilization, practical applications. (Cross listed as CIVL-6530. Students cannot obtain credit for both this course and CIVL-6530). Prerequisite: CIVL-2630 or permission of instructor. Spring term annually. 3 credit hours

ENVE-6130 Land Applications of Wastewater
Treatment efficiency and design parameters for different methods of treatment of wastewaters by land application. Methods considered include irrigation, rapid infiltration, overland flow, septic-tank leach field systems, and deep well injection. Soil geology and groundwater flow maintenance, monitoring of systems, and public health considerations. Evaluation of sludge disposal. Offered on availability of faculty. 3 credit hours
ENVE-6140 Stream Pollution Control
Principles of limnology applied to the ecological conditions of streams and bodies of fresh water relative to capacity to stabilize organic materials. The economic aspects of water pollution; health aspects of bacterial pollution. Spring term alternate years. 3 credit hours

ENVE-6150 Limnology
Classification and identification of microscopic and macroscopic aquatic plant and animal life. Chemical analysis sufficient to relate the organisms to their environment. Measurement of the physical characteristics of a lake. Field and laboratory studies on different aquatic systems. Classes conducted at Darrin Fresh Water Institute on Lake George. Prerequisite: permission of instructor. Offered on availability of faculty. 3 credit hours

ENVE-6160 Environmental Impact Analysis
Studies related to the evaluation of the impacts of major actions by state and federal agencies on the quality of human environment. Consideration is given to the preparation of impact statements. The impacts of various types of action are discussed; the adverse effects produced and alternatives to proposed action considered, and the trade-offs between short-term uses and long-term productivity are evaluated. Case studies are presented and analyzed. Open to graduate students in science or engineering. Offered on availability of faculty. 3 credit hours

ENVE-6170 Atmospheric Chemistry
The course presents important thermodynamic and kinetic aspects of reactions in the atmospheric layer. Consideration is given to transport phenomena in determining atmospheric compositions and kinetics. Applications of principles to upper atmospheric and lower (air pollution) atmospheric cases are discussed. Prerequisites: CHEM-2250, CHEM-2260, CHEM-4400 or equivalent or permission of instructor. Offered on availability of faculty. 3 credit hours

ENVE-6180 Air Pollution Meteorology
Investigation of atmospheric processes of particular importance in dealing with the environmental problems of air pollution: atmospheric turbulence, temperature lapse rates, wind profiles, plume rise, plume dispersion relations, urban dispersion models, wet and dry atmospheric scavenging processes, and inadvertent climate and weather modification. Open to graduate students in science or engineering. Prerequisites: ENGR-2050, CHEM-4400, ENVE-4330 or permission of instructor. Offered on availability of faculty. 3 credit hours

ENVE-6190 Public Health
Occurrence and control of communicable diseases; principles of epidemiology and biostatistics and their application, emphasizing the relationship with environmental factors; food infections and food poisoning; use and impact of pesticides and other methods of pest control; air pollution sources and health effects. Organization of government health agencies. Offered on availability of faculty. 3 credit hours

ENVE-6200 Hazardous Waste Management I
This course concentrates on management issues and study of the fate and transport of hazardous materials in the environment. Management topics are broken down into three broad categories: regulatory issues, those necessary for daily operation of an industrial facility (industrial hygiene, storage, and transportation issues), and preliminary environmental site assessments. Fate and transport issues will be dealt with quantitatively. Prerequisites: permission of instructor. Fall term annually. 3 credit hours

ENVE-6210 Hazardous Waste Management II
A continuation of ENVE-6200. The principal topic discussed is the selection of remediation alternatives and waste minimization. Prerequisite: ENVE-6200. Spring term annually. 3 credit hours

ENVE-6230 Mathematical Modeling of Environmental Engineering Systems
Basic modeling approaches and techniques for the simulation of environmental engineering systems. Model development, system conceptualization and analysis, mathematical representation, solution and simulation, as well as model calibration and verification, are discussed. Problems such as simulation of biochemical reactors and behavior of toxic chemicals in groundwater are drawn from the literature. Ongoing research projects are discussed. Spring term alternate years. 3 credit hours

ENVE-6240 Air Pollution Control
The major approaches to air pollution control are discussed from three viewpoints: equipment for particle and gaseous emissions control, control of specific processes and pollutants, control strategies. Emphasis is on control devices for particles, sulfur oxides, and nitrogen oxides; absorption with chemical reaction; wet scrubber technology. Combination with other approaches to develop control strategies. Prerequisite: ENVE-4330. Offered on the availability of faculty. 3 credit hours

ENVE-6250 Bench Scale Design
The design and operation of different laboratory experiments to provide experience for the environmental engineer in the practical application of chemical and biological theory. Design parameters are developed via bench scale testing. Topics include biological treatment, ion exchange, test for total carbon in a solid waste and PARR bomb calorimeter, soil columns, and microbial respirometry. Offered on availability of faculty. 3 credit hours
ENVE-6300 Bioremediation of Hazardous and Toxic Compounds
Lecture course stresses multidisciplinary approaches to the use of microbial system for biotransformation and biodegradation of toxic and hazardous material. Topics include biodegradability, enzymatic transformations, microbial ecology, and properties of organic and inorganic compounds, in situ and ex situ engineering techniques. Real world design examples and projects are introduced. Permission of instructor is required. ENVE-4350 or equivalent is recommended as a pre-requisite. Spring term. 3 credits

ENVE-6910 Colloquium Series
Seminars by distinguished guest speakers and graduate students on current problems in environmental and energy engineering. A broad range of subjects is covered. All undergraduates and graduates are strongly encouraged to attend as many lectures as possible. Fall and spring terms annually. 0 credit hours

ENVE-6940 Studies in Environmental Engineering 1 to 4 credit hours
ENVE-6960 Topics in Environmental Engineering 1 to 4 credit hours
ENVE-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work. 1 to 9 credit hours

ENVE-6990 Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

ENVE-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

ENVE-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 12 credit hours

EPOW Electric Power Engineering (SOE)
EPOW-4010 Power Engineering Fundamentals
Study of the principal components of electric power systems as individual pieces of equipment and as parts of a system. Balanced 3-phase circuits, per unit quantities. Circle diagrams, control of voltage, and power flow. Unbalanced faults. Symmetrical components. The study includes physical modeling and the use of standard software simulation tools. Prerequisite: ECSE-2010 or permission of instructor. Fall term annually. 4 credit hours

EPOW-4020 Electromechanics
This course studies electromechanical interactions in lumped-parameter systems. These interactions describe the operation of electric machines, electromechanical actuators and transducers. The fundamental laws of Faraday, Ampere and Gauss are considered to develop physical models of magnetic circuits, including those which use permanent magnets. These models are then expanded to include equations of motion and the thermodynamics of electromechanical coupling. Applications include transformers, induction machines, synchronous machines, DC machines, and reluctance machines. Prerequisite: ECSE-2010, ENGR-4300 or permission of instructor. Spring term annually. 3 credit hours

EPOW-4020 EPE Laboratory
A laboratory based examination of static and rotating energy conversion equipment. Topics include the experimental study of the physical phenomena and characteristics of magnetic circuits, transformers, electric machines, rectifiers, DC/DC converters and inverters. The interaction between static power converters and electric machines is emphasized. Prerequisites: EPOW-4020 or EPOW-4080 or permission of instructor. Spring term annually. 4 credit hours
EPOW-4080 Semiconductor Power Electronics
The application of power semiconductor devices to the efficient conversion of electrical energy. Circuit analysis, signal analysis, and energy concepts are integrated to develop steady-state and dynamic models of generic power converters. Specific topics include AC/DC conversion, DC/DC conversion, DC/AC conversion, and AC/AC conversion. These generic converters are applied as controlled rectifiers, switching power supplies, motor drives, HVDC transmission, induction heating, and others. Ancillary circuits needed for the proper operation and control of power semiconductor devices are also discussed. (Cross listed as ECSE-4080. Students cannot obtain credit for both this course and ECSE-4080.) Prerequisite: ENGR-4300 or ECSE-2050. Fall term annually. 3 credit hours

EPOW-4840 Industrial Power System Design
Industrial power system design considerations: planning (safety, reliability, simplicity, maintenance, flexibility, cost), voltages (control, selection, effects of variation), protection (devices, limitations, requirements, coordination, testing), fault calculations, grounding (static and lightning protection, earth connections), power factor control and effects, switching and voltage transformation, instruments and meters, cable construction and installation, busways. Prerequisite: EPOW-4010 or equivalent or permission of instructor. Spring term annually. 3 credit hours

EPOW-4850 Electric Power Engineering Design
A structured and integrated design experience in which a plurality of analytical tools is invoked to meet a design specification for a selected item of hardware. This will involve electrical, thermal, mechanical, environmental, and economic considerations, as appropriate, and may require laboratory and/or computer work in the design or evaluation. This is a writing-intensive course. May only be taken in the senior year. Prerequisites: EPOW-4010 and EPOW-4020 or permission of instructor. Spring term annually. 3 credit hours

EPOW-4940 Electric Power Engineering Project
1 to 6 credit hours

EPOW-4980 Senior Project
3 credit hours

EPOW-6090 Advanced Power Electronics Laboratory
A laboratory-based examination of rectifiers, DC/DC converters, resonant converters and inverters, focusing on the interactions among the semiconductor switches and the filter elements of the converter. Control circuits for the semiconductor switches are designed and implemented. Laboratory exercises consist of simulation and physical measurements. Transient performance of various converters is also examined. A student-initiated project dealing with some aspect of power electronics is required. Prerequisite: EPOW-4080 or permission of instructor. Spring term, even-numbered years. 3 credit hours

EPOW-6810 Power Engineering Analysis
Characteristics and equivalent circuits for transmission lines and transformers. Per unit system. Balanced three-phase systems and power transfer limits. Symmetrical components and sequence network characteristics of transmission lines and transformers. Symmetrical component fault analysis. Clarke components. Fall term annually. 3 credit hours

EPOW-6820 Power Quality Power Quality
Quality examines the causes of and solutions to electric power quality problems. Power quality topics range from utility issues such as voltage sags, swells, and outages to consumer issues, such as harmonic distortion, and bus reliability at the equipment level. Solution methods such as implementing surge suppressors, the UPS, active filtering, and proper grounding techniques will be discussed. It is recommended that students have taken either EPOW-6860 or EPOW-4080 prior to enrolling in this class. Spring term annually. 3 credit hours

EPOW-6830 Protective Relaying
Basic relaying philosophy. Current and potential transformers. Operating principles of electromagnetic, electronic and digital relays. Application of relays to protect generators, busses, transformers and transmission lines. Prerequisite: EPOW-4010. Corequisite: EPOW-6810. Fall term annually. 3 credit hours

EPOW-6840 Power Generation Operation and Control

EPOW-6850 Electric and Magnetic Fields in Electric Power Engineering
Review of electromagnetic theory required to undertake analysis and design of power equipment. Experimental, analog, and digital field estimation techniques. Case studies in electric and magnetic fields such as cable and bushing design, problems of gas bus systems, electrostatic precipitation, magnetic flux penetration, eddy currents, losses, shielding, generation of torque. Prerequisites: ECSE-2100, EPOW-4010, and EPOW-4020 or their equivalents. Fall term annually. 3 credit hours

EPOW-6860 Surge Phenomena in Electric Power Engineering
Analysis and computation of electrical transients in lumpy and distributed power circuits; switching surges, lightning surges, traveling waves. Impact of surges on terminal equipment. Insulation coordination; system protection; design of electric power apparatus and systems to operate reliably
and economically in a transient environment. Fall term annually.

**EPOW-6870 Mechanical Aspects of Electric Power Apparatus**

General theory of kinematics and dynamics of machines and structures with emphasis on power generating and distributing equipment. Special topics include basic concepts of vibration phenomena in mechanical systems, dynamic behavior of turbine-generator sets, self-excited vibrations in mechanical systems, earthquakes, circuit breaker linkages, short circuit forces on windings and bus structures. Prerequisite: permission of instructor. Spring term annually. 

3 credit hours

**EPOW-6880 The Utility as a Business**

The business aspects of electric utilities are highlighted, including source of funds, components of cost for generation, transmission, and distribution, the rate setting process, planning for future loads, least-cost system planning, and operation and economics of conservation. The course features the changing structure of electric utilities in the new regulatory environment and competition in this energy sector, especially for generation. Spring or summer term.

3 credit hours

**EPOW-6890 Computer Methods in Electric Power Engineering**

Applies the student's knowledge of power engineering to the solution of large problems by computer methods. Treats matrix techniques, load-flow analysis, network building, short circuit studies, numerical integration, and finite element analysis as it applies to power systems and power apparatus. Prerequisites: EPOW-6810 or equivalent or permission of instructor. Spring term annually.

3 credit hours

With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A,B,C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

**EPOW-6980 Master's Project**

Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.

1 to 9 credit hours

**EPOW-6990 Master's Thesis**

Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

1 to 9 credit hours

**ERTH Earth and Environmental Sciences (SOS)**

**ERTH-1010 Planet Earth I: The Solid Earth**

Age and origin of the Earth, internal constituents, and energy sources; how plates move, oceans develop, resources accumulate, and mountains rise. Gives nonspecialists a picture of the Earth's major processes and the ways in which they interact to provide the world's citizens with adequate material resources. Lectures and recitation. (Students cannot obtain credit for both ERTH-1010 and ERTH-1100.) Fall term annually.

4 credit hours

**ERTH-1020 Planet Earth II: Oceans and Atmosphere**

An overview of the Earth's surface processes and environ-
ment. Nature and interactions between the major oceanic, atmospheric, and terrestrial systems. Interrelations between geology, the environment, and human activities. Geologic and environmental implications, constraints, and opportunities for past, present, and future human populations and cultures. Short- and long-term benefits and consequences of actions or inaction. Lectures and recitation. (Students cannot obtain credit for both ERTH-1020 and ERTH-1200.) Spring term annually. 4 credit hours

**ERTH-1030 Natural Sciences I**

The sciences of the natural world, focusing primarily upon physics and chemistry but including some discussion of relevant topics in astronomy and planetary science. Both classical and modern concepts are treated, at scales ranging from the atom to the universe, and an effort is made to instill an appreciation for the nature of science and the scientific method. Examples are used as appropriate to illustrate the value of science in our everyday lives. The course is designed for nonscience majors and cannot be used by science majors to fulfill a distribution requirement. (Note: Natural Sciences II does qualify as a science distribution requirement for some science majors.) There are no prerequisites. Fall term annually. 4 credit hours

**ERTH-1040 Natural Sciences II**

The sciences of the natural world, focusing primarily on the earth and life sciences. The course addresses the origin, evolution, and current state of our planet, and examines the earth as a life-supporting system. Specific examples of developments in scientific thinking are used to illustrate connections among the various disciplines comprising the natural sciences. The course is designed for nonscience majors, and cannot be used by science majors to fulfill a distribution requirement. (Note: Natural Sciences II does qualify as a science distribution requirement for some science majors.) There are no prerequisites. Fall term annually. 4 credit hours

**ERTH-1100 Geology I: Earth's Interior**

Age and origin of the Earth, internal constituents and energy sources; how plates move, oceans develop, and mountains rise. The course aims to give a quantitative picture of the Earth's major processes and the ways in which they interact. Lectures and lab. (Students cannot obtain credit for both ERTH-1010 and ERTH-1100.) Fall term annually. 4 credit hours

**ERTH-1200 Geology II: Earth's Surface**

The geological environment of humankind: the atmosphere, oceans, groundwater, rivers, glaciers, deserts, and coasts. The course explores the processes by which these and other features develop and change, the opportunities or hazards they present, and the ways in which humans can modify their development. Lectures and lab. (Students cannot obtain credit for both ERTH-1020 and ERTH-1200.) Spring term annually. 4 credit hours

**ERTH-2100 Introduction to Geophysics**

An introduction to various aspects of the study of the physics of the Earth. Stress and strain, deformation, isostasy, seismic waves, earthquakes, Earth structure, resource exploration, Earth dynamics, plate tectonics, mountain building, gravity and geodesy, magnetic field, and heat flow. Included are weekly labs and occasional field exercises. Prerequisite: ERTH-1100. Spring term, odd-numbered years. 4 credit hours

**ERTH-2120 Structural Geology**

Introduction to stress and strain; observation, measurement, recording, and interpretation of rock structures including joints, faults, folds, and fabrics. Interpretation of structures from geologic maps. Structures and regional tectonics. Laboratory and field trips required. Prerequisite: ERTH-2210 or permission of instructor. Fall term annually. 4 credit hours

**ERTH-2140 Introduction to Geochemistry**

An introduction to the application of chemistry to problems in the Earth and Environmental Sciences. Topics include thermodynamics and phase equilibria as applied to mineral stability, rock evolution, and water chemistry; stable isotope systematics; radiogenic isotope systematics; trace element geochemistry, organic geochemistry, and geochemical cycles. (Cross listed as CHEM-2540. Students cannot obtain credit for both this course and CHEM-2540.) Prerequisite: ERTH-1100 and/or ERTH-1200, or permission of instructor. Spring term annually. 4 credit hours

**ERTH-2210 Field Methods**

Principles and methods of geologic mapping. Use of instruments. Selected field problems. Several field trips (usually on weekends) required. This course is writing intensive. Prerequisites: ERTH-1030 or ERTH-1100 or permission of instructor. Fall term annually. 4 credit hours

**ERTH-2330 Earth Materials**

Overview of the chemical and physical properties of the material constituents of the Earth and terrestrial planets, including minerals, rocks, lavas, and supercritical water. Topics include mineral structure and composition, bonding, optical properties, phase transformations, and surface properties. The role of minerals in the man-made environment is also discussed. Fall term annually. 4 credit hours

**ERTH-2610 Oceanography**

Ocean basins and margins; origin, distribution, chemistry, and history of sediments; physical and chemical properties of seawater; global atmospheric and oceanic circulations and climatic interactions. Prerequisites: CHEM-1100 and PHYS-1100 or permission of instructor. Fall term even-numbered years. 4 credit hours
ERTH-2620 Current Topics in Earth Science
This course provides the student with a formal participation in the weekly colloquium series of the Department of Earth and Environmental Sciences. These colloquia involve lectures on a wide variety of topics in the geologic and environmental sciences primarily by outside investigators who are currently active in those fields. (Students may take this course a maximum of two times for credit.) Prerequisites: geology or environmental science majors only or permission of instructor. Fall and spring terms annually.

1 credit hour

ERTH-4070 Sedimentology
Sediments and sedimentary rocks as part of the geologic cycles; the present as a key to the past. Sedimentary processes, products, and environments. Sedimentary strata as documents of geologic chronology. Includes a weekly laboratory and field trip(s). Spring term odd-numbered years.

4 credit hours

ERTH-4180 Environmental Geology
An overview of near-surface geological systems and human interaction with them, followed by a topical discussion of key geo- societal issues including, but not limited to, earthquake hazards, landslides, water pollution, waste disposal, and health risks posed by radon and asbestos. Spring term annually. Includes laboratory and one Saturday field trip.

1 credit hour

ERTH-4190 Environmental Measurements
Modern methods used in analysis of environmental samples for monitoring and research purposes. Standard and advanced techniques of air, water, sediment, and soil analysis are covered including spectrometric and chromatographic methods. (Cross listed as CHEM-4190. Students cannot obtain credit for both this course and CHEM-4190.) Prerequisite: permission of the instructor required. Lectures and lab. Fall term odd-numbered years.

4 credit hours

ERTH-4340 Igneous and Metamorphic Petrology
Introduction to the observation and interpretation of igneous and metamorphic rocks in outcrop, hand sample, and thin sections. Processes of melting, solidification and migration of magmas; solid state recrystallization and pressure-temperature histories. Heat flow and regional crustal dynamics. Laboratory and field trips required. Prerequisites: ERTH-2330 and ERTH-2140. Spring term even-numbered years.

4 credit hours

ERTH-4500 Global Environmental Change
Environmental issues of global concern will be investigated from a scientific perspective. Analysis of historic and current data bases on population, resources, land use, and climate will provide an introduction to detailed consideration of more specific case studies in areas including global warming, El Nino Southern Oscillation, ozone depletion, regional drought and water management, long-range transport of pollutants, species extinction and biological diversity loss. (Cross listed as IENV-4500. Students cannot obtain credit for both this course and IENV-4500.) Prerequisites: junior, senior or graduate student status. Fall term odd numbered years.

4 credit hours

ERTH-4540 Organic Geochemistry
A broad survey of organic geochemistry suitable for students with a strong chemistry background who are majoring in science or engineering. Topics include the transport and fate of organic pollutants and the geochemistry of natural organic compounds in oceans, lakes, sediments, and soils. (Cross listed as CHEM-4540. Students cannot obtain credit for both this course and CHEM-4540.) Prerequisites: CHEM-2210 and ERTH-1200 or permission of instructor. Spring term odd-numbered years.

4 credit hours

ERTH-4570 Solid Earth Geophysics
The course covers the physics of the Earth's interior, including a survey of its evolution, rotation, gravity and tides, seismicity, internal heat, magnetism, and tectonics. Prerequisite: ERTH-1100 or permission of instructor. On demand.

4 credit hours

ERTH-4650 Seismology
Introduction to the causes, consequences, and uses of vibrations in the Earth. Topics include elastic wave propagation, earthquake source mechanics, seismic risk analysis, exploration seismology, and tomographic imaging. Prerequisite: MATH-1020. Spring term on demand.

4 credit hours

ERTH-4690 Aqueous Geochemistry
Fundamentals of aqueous chemistry as applied to the evolution of natural waters. Principles of chemical equilibrium, activity models for solutes, pH as a master variable, concentration and Eh-pH diagrams, mineral solubility, aqueous complexes, ion exchange, and stable isotopes. The carbonate system, weathering reactions, and acid rain are examined in detail. Emphasis is on the chemical reactions that control surface and groundwater evolution in natural and engineered (treatment process) settings. Students learn theory, computation methods, and the use of computer programs for calculation of speciation and mass balance. (Cross listed as CHEM-4690 and ENVE-4110. Students cannot obtain credit for both this course and either CHEM-4690 or ENVE-4110.) Prerequisite: permission of instructor. Fall term annually.

4 credit hours

ERTH-4710 Groundwater Hydrology
Study of hydrologic, geologic, and other factors controlling groundwater flow, occurrence, development, chemistry, and contamination. Groundwater flow theory and aquifer test methods are introduced. Interactions between surface and subsurface hydrologic systems are covered.
Some field trips are possible. (Students cannot receive credit for both this course and ERTH-6710.) Prerequisite: MATH-1020 or equivalent or permission of the instructor. Fall term annually. 4 credit hours

ERTH-4740 Applied Groundwater Modeling
Study of numerical solutions to the ordinary and partial differential equations of groundwater flow and contaminant transport. Emphasis on modeling methodology and solving applied problems. Prerequisite: ERTH-4710 or ERTH-6710 or permission of instructor. Spring term odd-numbered years. 4 credit hours

ERTH-4750 Geographic Information Systems in the Sciences
Introduction to analysis and interpretation of spatial data and their presentation on maps (using MapInfo software). Concepts of map projections, reference frames, multivariate analysis, correlation analysis, regression, interpolation, extrapolation, and kriging will be covered. Prerequisite: knowledge of Windows OS. Spring term annually. 4 credit hours

ERTH-4810 Chemistry of the Environment
Chemical processes important in the environment from naturally occurring and man-induced systems. Thermodynamic and chemical considerations of fuels; the thermodynamics of the atmosphere; atmospheric photochemistry; chemistry of natural water systems; chemistry of pesticides, fertilizers, and other important environmental contaminants; aspects of the carbon, nitrogen, and sulfur cycles. (Cross listed as CHEM-4810. Students cannot obtain credit for both this course and CHEM-4810.) Prerequisites: CHEM-1200 and one prior or concurrent course in organic chemistry or permission of instructor. Spring term annually. 4 credit hours

ERTH-4940 Readings in Geology 1 to 4 credit hours

ERTH-4960 Topics in Geology 1 to 4 credit hours

ERTH-4970 Out-of-Classroom Experience in Earth Sciences
Credits are earned while the student gains practical experience in applying skills to working in a private company or government agency in an area relevant to the student's educational goals. Requires a written proposal and final report. 2 to 4 credit hours

ERTH-4980 Senior Field Thesis
Independent field experience for undergraduates. Requires a written proposal and final report. 2 to 4 credit hours

ERTH-6300 Advanced Metamorphic Petrology
In-depth analysis of metamorphic phase equilibria in pelites, amphibolites, carbonates, and ultramafic rocks. Schreinemakers' analysis, petrogenetic grids, P-T-X relations, reaction space, geothermometry, geobarometry, and analysis of zoned prophyroblasts. Heat flow, metamorphic, and tectonic evolution. Laboratory involves analysis of textural relations in thin section and computer exercises. Fall term odd-numbered years. 4 credit hours

ERTH-6540 Advanced Igneous Petrology
Topical treatment of current problems and frontiers in igneous petrology, with emphasis on physical and chemical processes. Principles of fluid dynamics and chemical kinetics are applied to the formation and evolution of crust- and mantle-derived magmas. Prerequisite: ERTH-4340. Spring term odd-numbered years. 3 credit hours

ERTH-6580 Seminar in Geophysics: Selected Topics
General topics in advanced geophysics vary each time the seminar is offered. Previous subjects covered include crustal deformation, inverse theory, global positioning system, and seismic wave propagation. Prerequisite: permission of instructor. Spring term even-numbered years. 3 credit hours

ERTH-6710 Advanced Groundwater Hydrology
An intensive study of hydrologic, geologic, and other factors controlling groundwater flow, occurrence, development, chemistry, and contamination. Groundwater flow theory and aquifer test methods are introduced. Interaction between surface and subsurface hydrologic systems are covered. Some field trips are possible. (Students cannot receive credit for both this course and ERTH-4710.) Prerequisites: MATH-1020 or equivalent, or permission of instructor. Fall term annually. 3 credit hours

ERTH-6720 Advanced Groundwater Hydraulics
An in-depth, quantitative treatment of fluid flow in subsurface media. Derivation of the fluid flow equation followed by application to various hydrologic situations, including flow to wells. Emphasis on analytic solutions and their assumptions. Some field trips are possible. Prerequisites: knowledge of differential equations and vector calculus, ERTH-6710 or equivalent, or permission of instructor. Spring term annually. 3 credit hours

ERTH-6730 Groundwater Contaminant Transport
Theoretical and applied study of solute transport phenomena. Analytical and numerical solutions of the advection-dispersion equation and other techniques for solving groundwater contaminant transport problems. Issues of contamination sources, basic chemical concerns during transport, and monitoring and remediation are also covered. Transport modeling is also introduced. Some field trips are possible. Prerequisites: MATH-4600 or equivalent, ERTH-4710 or ERTH-6710 or equivalent, or permission of instructor. Spring term annually. 3 credit hours

ERTH-6940 Readings in Geology 1 to 4 credit hours

ERTH-6960 Special Topics in Geology
Topics offered previously: geomagnetism, seismology, min-
eral equilibria; mineral structures; igneous minerals and rocks; sedimentary processes; marine geology, convergent plate margins, geoeexploration, remote sensing applications, seismic stratigraphy; physical oceanography.

ERTH-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

ERTH-6980 Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

ERTH-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

ESCI Engineering Science (SOE)

ESCI-6980 Master's Project
Active participation in a Master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the library. Grades will then be listed as S. 1 to 9 credit hours

ESCI-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

ESCI-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

IENV Interdisciplinary Environmental Courses

IENV-1910 Environmental Seminar
A weekly seminar required for students who are beginning their degree program in environmental science and open to other first-year students. Speakers include faculty, graduate students, and guest environmental professionals. Topical environmental issues are considered from numerous perspectives. Fall term annually. 2 credit hours

IENV-2100 Introduction to Environmental Studies
An introduction to a variety of ways to study the environment, especially science and technology studies, environmental science, and environmental engineering. Case studies and projects emphasize the cooperation of disciplines in addressing local and global environmental issues such as PCBs in the Hudson River, acid rain in the Adirondacks, and population growth. (Cross listed as IHSS-2100. Students cannot obtain credit for both this course and IHSS-2100.) Spring term annually. 4 credit hours
IENV-4500 Global Environmental Change
Environmental issues of global concern will be investigated from a scientific perspective. Analysis of historic and current data bases on population, resources, land use, and climate will provide an introduction to detailed consideration of more specific case studies in areas including global warming, El Nino Southern Oscillation, ozone depletion, regional drought and water management, long-range transport of pollutants, species extinction and biological diversity loss. (Cross listed as ERTH-4500. Students cannot obtain credit for both this course and ERTH-4500.) Prerequisites: junior, senior, or graduate student status. Fall term odd numbered years.

4 credit hours

IENV-4700 One Mile of the Hudson River
A course that focuses on the Hudson River Basin as an environmental microcosm and a vehicle through which to illustrate the natural science of river systems with particular attention to human influences. This interdisciplinary environmental science course is for environmentally oriented junior, senior, and graduate students. Prerequisites: junior, senior, or graduate student status; introductory courses in biology, chemistry, and geology; environmentally oriented humanities/social sciences courses, or permission of instructor. Fall term, even-numbered years.

4 credit hours

IHSS Interdisciplinary Humanities and Social Science Studies (HSSH)

IHSS-1210 Information Technology Revolution: Myth or Reality?
This course examines a broad spectrum of information technologies, from alphabets, calendars, and the first world maps to GIS and GPS; from telephones and radio to cybernetics, the gene chip, and quantum cryptography; from the first computer to the Internet. One goal is for students to learn how technological innovation happens and affects the world. Another goal is to explore the history of IT, teaching students how to use the past to “think the future.” (Cross listed as ITEC-1210. Students cannot obtain credit for both this course and ITEC-1210.) Fall term annually.

4 credit hours

IHSS-1220 Politics and Economics of Information Technology
Will IT increase prosperity? For whom? What role should governments play in IT development? Do corporations have new responsibilities in the Information Era? What about IT professionals? This course explores the issues, the arguments, and the working solutions. The first section examines macro indicators and trends. The second section examines the microeconomics and politics of specific arenas—the software industry, the automated work place, telemedicine, television. The last section explores opportunities for improving society using IT. (Cross listed as ITEC-1220. Students cannot obtain credit for both this course and ITEC-1220.) Spring term annually.

IHSS-1500 Product Design and Innovation Design Studio I
The first design studio in the Product Design and Innovation Program introduces students to general design through a series of short projects. The projects stress creative thinking and invention, observation and perception, communication and visualization, sketching, photography, model-making, and especially open-ended exploration. Fall term annually.

4 credit hours

IHSS-1960 Topics in Interdisciplinary Humanities and Social Science Studies

IHSS-2100 Introduction to Environmental Studies
An introduction to a variety of ways to study the environment, especially science and technology studies, environmental science, and environmental engineering. Case studies and projects emphasize the cooperation of disciplines in addressing local and global environmental issues such as PCBs in the Hudson River, acid rain in the Adirondacks, and population growth. (Cross listed as IENV-2100. Students cannot obtain credit for both this course and IENV-2100.) Spring term annually.

IHSS-2500 Product Design and Innovation Studio III
This studio design course focuses on an enriched sense of problem definition through an emphasis on the reach and interconnectedness of technology, and the conditionality of design selection criteria. Its design exercises, readings, and discussion press beyond marginal substitutions toward a broadened sense of possibility from, for example, “hyper-cars” and human-powered homes to small-scale local agriculture and extreme ecological living systems. Prerequisite: PDI I or PDI II or permission of instructor. Fall term annually.

4 credit hours

IHSS-2960 Topics in Interdisciplinary Humanities and Social Science Studies

IHSS-4800 Experiential Learning Project
This is an individually tailored reading course in which the student does readings and also completes an internship-type field project for the minor in cross-cultural studies of science and technology. The goal is to provide students with immersion in a multicultural milieu involving science and technology issues. Projects include student exchange...
programs, co-op placement, public service internships, community service, and other individually tailored projects subject to adviser approval. Students are expected to write up a description of their field project that integrates their field experience with the readings. Prerequisite: completion of other course requirements for the minor. Offered on demand. 3 credit hours

IHSS-4960 Topics in Interdisciplinary Humanities and Social Science Studies 3 credit hours

IHSS-6960 Topics in Interdisciplinary Humanities and Social Science Studies 3 credit hours

ISCI General Interdisciplinary Courses (SOS)

ISCI-4500 Topics in Origins of Life
Study or research in areas relevant to origins of life, to demonstrate interest in and ability for independent work. Prerequisite: junior standing or higher or permission of instructor. Fall and spring terms annually. 3 or 4 credit hours

ISCI-4510 Origins of Life Seminar
Discussion of current issues relevant to origins of life, in astrophysics, biology, chemistry, and earth sciences. Prerequisite: junior standing or higher or permission of instructor. ISCI-4510 will be graded satisfactory/unsatisfactory and it cannot be counted towards the Institute’s baccalaureate requirement of 24 credits in the sciences. Fall and spring terms annually. 1 credit hour

ISCI-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A professional project often serves as a culminating experience for a professional master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one professional project. Professional projects must result in documentation established by each department or school, but are not submitted to the Office of Graduate Education and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work. 3 to 4 credit hours

ISCI-6980 Master’s Project
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

ISCI-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

ISCI-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

ITEC Information Technology (IT)

ITEC-1210 Information Technology Revolution: Myth or Reality?
This course examines a broad spectrum of information technologies, from alphabets, calendars, and the first world maps to GIS and GPS; from telephones and radio to cybernetics, the gene chip, and quantum cryptography; from the first computer to the Internet. One goal is for students to learn how technological innovation happens, and affects the world. Another goal is to explore the history of IT, teaching students how to use the past to “think the future.” (Cross listed as IHSS-1210. Students cannot obtain credit for both this course and IHSS-1210.) Fall term annually. 4 credit hours

ITEC-1220 Politics and Economics of Information Technology
Will IT increase prosperity? For whom? What role should governments play in IT development? Do corporations have new responsibilities in the Information Era? What about IT professionals? This course explores the issues, the arguments and working solutions. The first section examines macro indicators and trends. The second section examines the microeconomics and politics of specific arenas — the software industry, the automated work place, telemedicine, television. The last section explores opportunities for improving society, using IT. (Cross listed as IHSS-1220. Students cannot obtain credit for both this course and IHSS-1220.) Spring term annually. 4 credit hours
ITEC-2110 Exploiting the Information World
This course involves a study of the methods used to extract and deliver dynamic information on the World Wide Web. The course uses a hands-on approach in which students actively develop Web-based software systems. Additional topics include installation, configuration, and management of Web servers. Students are required to have access to a PC on which they can install software such as a Web server and various programming environments. Prerequisites: CSCI-1200 or equivalent. Fall term annually. 4 credit hours

ITEC-2210 Introduction to Human Computer Interaction
An introduction to the current theories, methods, and issues in human-computer interaction. Theory and research along with practical application are discussed within the context of organizational impact. The course provides the knowledge of HCI systems and research used for the implementation of safe, quick, and usable interactive technologies. (Cross listed as PSYC-2210. Students cannot obtain credit for both this course and PSYC-2210.) Fall term annually. 4 credit hours

ITEC-4100 ITEC Capstone Experience
Students work on collaborative projects to design innovative IT solutions which address a specific problem or area of need in the student’s field. Students work to identify a problem and research viable solutions. They go on to propose, design, and prototype their IT solution learning best practices for IT project management, communication, and user-center design, This course serves as the culminating experience for the undergraduate IT program. Restricted to ITEC majors. Prerequisites: ITEC-2210 and ITEC-4310. This is a writing-intensive class. Fall term annually. 4 credit hours

ITEC-4310 Managing IT Resources
This course provides an introduction to fundamental concepts of management and applies them to IT. It examines the use of IT in business processes and the management issues of integrating IT into organizational processes to gain competitive advantage. Topics include: management, organizations, and information systems; development life cycle; project management and systems engineering; process reengineering; and organizational learning. This course includes the planning, development, and implementation of an IT project for a real client. Prerequisites: ITEC-2110 or permission of instructor. Fall term annually. 4 credit hours

ITEC-6800 IT Master’s Capstone
Integration of the knowledge and professional practice of the Master’s in IT core and concentration courses. Topics in database systems, networking, software design, human computer interaction, management of technology, and ethics are applied within a framework of global e-business strategy. The course utilizes a Team Project with a real organization to practice major IT concepts. Team members select, develop, and present a significant technology implementation project, incorporating strategy, systems development and business planning. (Cross listed as DSES-6800. Students cannot get credit for both this course and DSES-6800.) Spring term annually. 3 credit hours

ITEC-6980 Master’s Project
Active participation in a master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser and the Office of Graduate Education to then be archived in a standard format in the library. Grades will then be listed as S. 3 to 4 credit hours

ITEC-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 3 to 6 credit hours

LANG Foreign Languages and Literature (HSSH)
(Note: It is not necessary to take a second semester of a foreign language to receive credit for the first.)

LANG-1110 French I
This introductory course deals with the basic elements of the French language and, in so doing, places equal stress on speaking, listening, and writing abilities, using daily-life vocabulary. Intensive oral drills designed to teach good speaking habits make class attendance compulsory. This course is enhanced by the use of audio-visual materials whose purpose is to expose the student to contemporary broadly based French culture which constitutes the foundation for an end of the semester paper (in English). Fall term annually. 4 credit hours

LANG-1120 French II
This course, a continuation of French I, is a practical approach to everyday situations through the development of listening, speaking, and writing abilities. Intensive oral drills of a more complex nature designed to achieve fluency, make class attendance compulsory. The reading of short anecdotes on French life provides exposure to written French. This course is enhanced by the use of audio-visual materials designed to expose the student to contemporary French culture which constitutes the basis for an end of the semester paper (in English). Prerequisite: LANG-1110 or permission of the instructor. Spring term annually. 4 credit hours
LANG-1210 Japanese I
Introduction to basic aspects of Japanese grammar, conversation, reading, and writing. Practice with everyday situations with focus on various features of Japanese life and culture. Full term annually. 4 credit hours

LANG-1220 Japanese II
Continuation of Japanese I. Grammar, conversation, reading and writing will be emphasized. The course will focus on various features of Japanese life and culture. The class will consist of short lectures with various communication drills, written and spoken. Approximately 30 Kanji characters will be introduced. Prerequisite: LANG-1210 or permission of instructor. Spring term annually. 4 credit hours

LANG-1310 German I
Introductory course in the basic elements of German language and aspects of contemporary culture. Equal stress on speaking, reading, writing, and listening. Cultural materials used as a basis for reading comprehension and elementary conversation. Fall term annually. 4 credit hours

LANG-1320 German II
Continuation of German I, supplemented by authentic readings in literature and culture. Presupposes a basic knowledge of German grammar and vocabulary such as acquired in German I. Spring term annually. 4 credit hours

LANG-1410 Chinese I
This course assumes no previous knowledge of the subject. The course is designed to provide students with fundamental skills in listening, speaking, reading, and writing Mandarin Chinese. Oral and aural skills will be emphasized. Background on Chinese culture will be introduced as an element of the course. Fall annually. 4 credit hours

LANG-2110 French III
This course takes a two-pronged approach to conversational fluency, writing competency, and reading skills by offering a review and an expansion of grammar through grammatical exercises and by providing audio-visual materials and texts that focus on various aspects of French culture while raising cross-cultural awareness. The learning and practice of an extensive vocabulary give the student the wherewithal to write an end of the semester essay in French on an aspect of French culture. Prerequisite: LANG-1120 or permission of instructor. 4 credit hours

LANG-2120 French IV
This course is a continuation of French III. While similar in form and content, the audio-visual materials and texts offered stress the accomplishments of the Francophonie in the arts and sciences. Prerequisite: LANG-2110 or permission of the instructor. Spring term annually. 4 credit hours

LANG-2210 Japanese III
Continuation of Japanese II. The course reinforces fundamental skills introduced in Japanese I and II and further develops functional ability to communicate in Japanese beyond the elementary level. The class consists of short lectures with various communication activities, written and spoken. Aspects of contemporary Japanese culture will also be discussed. Approximately 45 new Kanji characters will be introduced. Prerequisite: LANG-1210 and LANG-1220 or consent of instructor. Fall term annually. 4 credit hours

LANG-2220 Japanese IV
Continuation of Japanese III. This course will extend the knowledge and the skills acquired in Japanese I through III to the intermediate level. The course will further develop fluency in conversational skill while reading and writing skills of more complex texts are emphasized. Approximately 120 new Kanji characters will be introduced. Prerequisite: LANG-1210, LANG-1220, and LANG-2220 or consent of instructor. Spring term annually. 4 credit hours

LANG-2310 German III
Discussion of readings in contemporary German culture and literature. Further development of the skills acquired in German I and II. The entire course is conducted in German. Prerequisite: LANG-1320 or permission of instructor. Fall term annually. 4 credit hours

LANG-2410 Chinese II
This is a continuation of Chinese I. The course is designed to provide students with fundamental skills in listening, speaking, reading, and writing Mandarin Chinese. Oral and aural skills continue to be emphasized. Background information on Chinese culture will be introduced as an element of the course. Spring annually. 4 credit hours

LANG-2940 Language Studies
Experimental courses tried out in one or two terms. 4 credit hours

LANG-2960 Topics in Language
Readings and projects adapted to the needs of individual students. 4 credit hours

LANG-4210 French Readings in the Arts and Sciences
This course introduces the student to the written French in the Arts and Sciences. The student is taught the grammar and the translation techniques needed to translate texts from French into English. The texts chosen cover a wide range of literature, from the literary to the more popular genres of mass communications. The course is intended for those who will take the foreign language proficiency examination and is useful for those who plan to work for a multinational company. A grade of A or B satisfies the language requirement. Prerequisite: prior knowledge of French required. Open only to graduate and senior students. No core program credit. Spring term annually. 4 credit hours
LANG-4400 Business French I
This course surveys the technical and cultural aspects of the French business world within its geographical, social, and political context. It provides the student with insights into the social and political make-up of French society as they affect the economy of France and her trading partners. It introduces the vocabulary and the essential tools needed by business professionals and requires an extensive practice in business writing and communication. Audiovisual materials supplement the text by helping the student to discover the French business world and its language and by bridging the gap between French and American business cultures. Prerequisite: LANG-2120 or permission of the instructor. Fall term annually. 4 credit hours

LANG-4410 Business French II
This course is a continuation of Business French I using the same format. It constitutes the second part of a two-course series. Prerequisite: LANG-4400. Spring term annually. 4 credit hours

LANG-4460 Chinese III
This is a continuation of Chinese II. This course extends our knowledge of basic grammar and vocabulary (including reading and writing characters) in preparation for work with original Chinese texts. We will begin to use a Chinese dictionary. In addition to Chinese-English, English-Chinese translation, we will compose short passages in Chinese. We will also continue with Chinese computing and design our own Web page. Various aspects of Chinese culture and society will also be studied. Prerequisite: LANG-1410 and permission of instructor. Fall annually. 4 credit hours

LANG-4940 Language Studies
Readings and projects adapted to the needs of individual students. 4 credit hours

LANG-4960 Topics in Language
Experimental courses tried out in one or two terms. 4 credit hours

LANG-6940 Language Studies
Readings and projects adapted to the needs of individual students. 3 credit hours

LGHT Lighting (SOA)

LGHT-4230 Lighting Design
A design studio that explores the roles of light in architecture and its application by design. Students conceive, evaluate, and synthesize solutions that contribute to successful lighting and architectural design. Prerequisite: LGHT-4770. Corequisite: LGHT-4790. Spring term annually. 4 credit hours

LGHT-4770 Lighting Technology
This course familiarizes students with the basic components of lighting systems and enables them to critically explore applications of those components. Through lectures, readings, and assignments, students acquire working knowledge of the relevant products and techniques for architectural lighting and the skills necessary to apply them in developing solutions to lighting problems. Fall term annually. 4 credit hours

LGHT-4790 Lighting Applications
Practical applications of lighting principles and design and specification skills. These skills include interpretation of architectural media, design presentation techniques, application of photometric data, use of manual and computer-based lighting calculations, and appraisal of lighting equipment. Lectures, hands-on assignments, and application projects. Prerequisite: LGHT-4770. Corequisite: LGHT-4230. Spring term annually. 4 credit hours

LGHT-4830 Light
An introduction to the physics of light and its applications for lighting. Laboratory sessions are included to emphasize important concepts and to illustrate applications. Topics include geometric optics, physical optics, radiometry, and photometry. Corequisite: LGHT-4770 or permission of instructor. Fall term annually. 4 credit hours

LGHT-4840 Human Factors in Lighting
An introduction to lighting and human factors, including classical literature and contemporary studies and development of skills needed to conduct and evaluate human factors research. Fall term annually. 4 credit hours

LGHT-4940 Advanced Individual Projects in Lighting
Individual projects and readings adapted to the needs of individual students at the advanced level. 1 to 6 credit hours

LGHT-6750 Lighting Research Design
An introduction to the philosophy of research and different approaches to it. Emphasis is placed on planning, executing, analyzing, and describing experiments. Each student is required to keep a laboratory notebook and to perform statistical tests in concert with assigned research projects. Spring term annually. 4 credit hours

LGHT-6760 Lighting Workshop
The development of skills in lighting research or design through completing projects under faculty guidance. Students have options to pursue topics that develop skills suited to their career goals in lighting. In all cases, project work includes investigation, reporting, and presentation of findings or proposals. Prerequisites: LGHT-4230 or LGHT-6750. Fall term annually. 8 credit hours
LGHT-6780 Lighting Leadership Seminar
A series of topics and case studies to prepare students for leadership roles in the lighting industry. Topics relate to product innovation and factors influencing changes of policy and processes in the lighting industry and involve lecture and discussion sessions and reading assignments. Case studies examine selected topics in greater depth, using actual situations to illustrate interactions of technology and business forces. Spring term annually. 4 credit hours

LGHT-6940 Advanced Individual Projects in Lighting
Individual projects and readings adapted to the needs of individual students at the advanced level. 1 to 6 credit hours

LGHT-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

LITR Literature (HSSH)

LITR-2110 Introduction to Literature
A study of major literary works that introduces students to basic ideas and terminology in literary criticism. Students learn to read and interpret a selection of novels, plays, poetry, or other forms of writing to be determined each semester by the instructor. Spring term annually. 4 credit hours

LITR-2150 Contemporary Literature
A study of significant works of world literature of the 20th century. Each work provides the student with a concrete experience of some overriding problem of our time—for example, the difficulty of becoming one’s self in the modern age. Fall and spring terms annually. 4 credit hours

LITR-2310 The Human Mind in Fiction
Works of literature reflect theories about the human mind. Just as people have vigorously debated theories about the movement of planets in the material world, they have proposed radically different notions of the mental world. All seek to explain emotion, reason, dreams, and memory. Drawing on material from Homeric Greece to 20th-century cyber-culture, this course pairs one psychological explanation of mind with a corresponding literary work. Fall term alternate years. 4 credit hours

LITR-2350 Shakespeare
A study of the major plays of William Shakespeare, including his comedies, histories, and tragedies. As well as textual discussion, students will have an opportunity to view film versions of the dramatic works and to perform or read extracts in class. Spring term annually. 4 credit hours

LITR-2360 The Novel
Study of about seven representative novels. Each book is reviewed as a unique work of art, as an outgrowth of certain traditions, as a mirror of its time, and as an expression of one author’s personal vision of human nature and the human condition. Fall term alternate years. 4 credit hours

LITR-2420 Art of the Film
A survey of selected films whose directors have contributed to the resources of the medium, as well as a study of technical and aesthetic considerations that distinguish film from other arts. Reading assignments in film history, techniques, scripts, and special research projects. Spring term annually. 4 credit hours

LITR-2450 Utopian Literature
An exploration of the use of fiction to propagate ideas about ideal or nightmarish societies. This course examines the artistic techniques employed in this distinct tradition and the unusual interplay between fiction and reality that this popular genre represents. Students work toward the design of their own utopian scheme in short story or other form. Fall term alternate years. 4 credit hours

LITR-2460 Black Film
A survey of black films of the 20th century and an analysis of the plot, theme, cultural construction, characterization, moral, philosophical implications, blacks images, and historical context to black life and national conditions. Offered on availability of instructor. 4 credit hours

LITR-2470 Study of African-American Literature
This course provides an introduction to black authors and their literary contributions and an analysis of their relationship to black thought and culture. Various forms of literature, such as folk tales, poetry, short story, prose, and essay, will be presented with emphasis on literary style and content as influenced by the social environment of the periods of America’s historical development from 1619 to the present. Students will write about these works in class, including a thirty-page (typed) critical research paper outside of class. Workshops, lectures, oral reports, and group discussions will be the methodology for each class session. Offered on availability of instructor. 4 credit hours

LITR-2500 The Short Story
A study of outstanding short stories from 19th- and 20th-century Europe and America, usually including works by such writers as Boccaccio, Flaubert, Chekhov, Borges, Ellison, Faulkner, Hemingway, Chopin, Joyce, Kafka, O’Connor, and Welty. Offered on availability of instructor. 4 credit hours

LITR-2540 Modern Drama
A survey of the work of modern dramatists such as Shaw, Ibsen, and O’Neill, as well as more contemporary playwrights such as Miller, Williams, Brecht, Beckett, Orton, and Stoppard. Offered on availability of instructor. 4 credit hours
LITR-2770 Women Writers
A study of works of literature written by women, featuring such writers as Jane Austen, Charlotte Bronte, Emily Bronte, George Eliot, and Virginia Woolf, and including the work of selected contemporary writers. Fall term annually. 4 credit hours

LITR-2940 Literature Studies
Readings and projects adapted to the needs of individual students. 4 credit hours

LITR-2960 Topics in Literature
Experimental courses tried out in one or two terms. 4 credit hours

LITR-4150 Science and Fiction
An exploration of the ongoing dialogue between science/technology and literature through the reading of landmark works about science and fictional works that describe scientific ideas and methods. Topics include artificial intelligence, genetic engineering, and cyborgs. Offered alternate years. 4 credit hours

LITR-4210 Humor, Comedy, and Satire
Readings of literature from various periods in these three modes, including works by classical, renaissance, and contemporary writers. May include film, videos, and audio recordings. Prerequisite: one literature course. Spring term alternate years. 4 credit hours

LITR-4410 Film Theory
The purpose of this course is to study significant theories of representation that analyze the visual codifications generically called “film.” We will examine theories of visual rhetoric and of narrativity; look at the way economic and technological factors have affected the construction of cinematic codes, styles, and trends; examine influential psychoanalytic theories and feminist theories; and consider the ways in which popular films participate in the cultural narratives specific to their moment of production. Prerequisite: any film course or permission of instructor. Offered annually. 4 credit hours

LITR-4450 Nonwestern Fiction and Film
This course explores the work of indigenous writers and filmmakers from the Pacific Islands, Africa, India, and China and considers how local/native, national, and transnational identities are constructed through their voices. The books and films studied deal with immigrant experience, the condition of diaspora, the politically self-conscious invention of a national voice, and critique of the postcolonial nation state. Prerequisite: any film course or permission of instructor. Spring term annually. 4 credit hours

LITR-4960 Topics in Literature
Experimental courses tried out in one or two terms. 4 credit hours

LITR-6330 Critical Theory
Focuses on the major philosophical, political, and psycho-logical theories that have shaped literary studies since 1965. Students will be introduced to major theories [including Deconstruction, Psychoanalysis (Freud-Lacan), Marxism, Feminism] and to a series of topics that ask students to integrate two or more of these theories. Prerequisite: graduate standing or permission of instructor. Offered on availability of instructor. 3 credit hours

LITR-6940 Literature Studies
Readings and projects adapted to the needs of individual students. 3 credit hours

LITR-6960 Topics in Literature
Experimental courses tried out in one or two terms. 3 credit hours

MANE Mechanical, Aerospace, and Nuclear Engineering (SOE)

MANE-2060 Fundamentals of Flight
An introduction to the elements of fluid mechanics, thermodynamics, heat transfer, aerodynamics, aircraft and rocket propulsion, launch systems, spaceflight dynamics, and reentry mechanics. Application of this material to airplane performance calculations and to airplane and spacecraft design. Spring term annually. 4 credit hours

MANE-2400 Fundamentals of Nuclear Engineering
Nuclear reactor systems and types; basic reactor physics, criticality calculations; fuel cycles; reactivity changes; reactor kinetics. Instrumentation and control; radiation protection. Reactor materials; shielding; energy removal. Reactor safety; economics. Waste management. Reactor design. Prerequisite: ENGR-2830 or equivalent. Fall term annually. 4 credit hours

MANE-2940 Readings in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
1 to 3 credit hours

MANE-2960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
3 credit hours

MANE-2980 Senior Project
Fall and spring terms annually. 3 credit hours

MANE-4010 Thermal and Fluids Engineering II
Application of thermodynamics, heat transfer, and fluid flow principles to practical engineering systems, including power generation, HVAC, automotive design, materials processing, etc. Extends and complements concepts introduced in ENGR-2250. Utility of the 2nd Law will be demonstrated and emphasized. Prerequisite: ENGR-2250. Fall and spring terms annually. 4 credit hours
MANE-4020 Thermal and Fluids Engineering Laboratory
Laboratory experience to complement MANE-4010. Demonstration of principles of thermodynamics, heat transfer, and fluid mechanics for mechanical engineering applications through a number of structured experiments. Corequisite: MANE-4010. Fall and spring terms annually.
2 credit hours

MANE-4030 Elements of Mechanical Design
Introduction to the design of mechanical components and integrated assemblies. Loads, stresses, and strains. Failure phenomena. Mechanical components including shafts, couplings, bearings, gears, springs, clutches, brakes, screws and fasteners, and bonded joints. Prerequisites: MATH-2400, ENGR-2530. Fall and spring terms annually. 4 credit hours

MANE-4040 Mechanical Systems Laboratory
Laboratory experience to complement MANE-4030. Stress and strain measurement; load, fatigue, and failure testing; friction and wear behavior. Reverse engineering of a mechanical assembly. Corequisite: MANE-4030. Fall and spring terms annually. 2 credit hours

MANE-4060 Aerospace Structural Analysis
Beam structures under combined shear, bending, and torsional loads. Semi-monocoque structures: idealizations involving wings, ribs, and fuselage bulkheads. Effects of taper and cutouts in stiffened shell structures, shear deformations and warping, location of elastic axis in open and closed sections, torsion of multicell sections. Stability of beam and membrane elements. Prerequisite: ENGR-2530. Fall term annually. 3 credit hours

MANE-4070 Aerodynamics I
The fundamental principles of fluid dynamics, theory of inviscid incompressible flow, thin airfoils, high aspect ratio wings, delta wings, vortex panel and vortex lattice methods, subsonic compressible small-disturbance theory, transonic flow. Prerequisites: ENGR-2250 and MANE-2060. Fall term annually. 3 credit hours

MANE-4080 Propulsion Systems
Analysis of thrust generation: propeller theory, combustion, reciprocating engines, gas turbines. One-dimensional compressible flow, Prandtl-Meyer expansions and oblique shock waves, application to diffusers and rocket nozzles. Linearized supersonic flow. Prerequisite: MANE-4070 or permission of instructor. Fall term annually. 3 credit hours

MANE-4090 Flight Mechanics

MANE-4100 Spaceflight Mechanics
Review of basic dynamics. Analysis of spacecraft trajectories, target rendezvous, and interception. Hohmann transfer, escape trajectories, interplanetary missions, the restricted three-body problem. Rigid body dynamics with application to gyrodynamics, stabilized platforms, gravity-gradient and spin stabilization of satellites, gyrostats. Selected topics such as drag-free satellites, vehicle launch and reentry, deployment dynamics (time permitting). MATLAB/Simulink is used as a simulation-visualization aid. Prerequisites: ENGR-2090, MANE-2060, and MATH-2400, or equivalent. Fall term annually. 4 credit hours

MANE-4110 Advanced Fluid Mechanics
Comprehensive treatment of fluid mechanics for both incompressible and compressible as well as viscous and inviscid flows, with emphasis on fundamental concepts and analytical methods. Topics include review of kinematics of fluid flow, derivation of the Navier-Stokes equations including their boundary conditions, exact solutions of Navier-Stokes equations, similarity solutions including laminar boundary layers, transition to turbulence, and one- and two-dimensional ideal compressible flow. Prerequisite: MANE-4010 or equivalent. Offered on sufficient demand. 3 credit hours

MANE-4130 Analysis and Design of Composite Structures

MANE-4150 Stresses in Machine Elements
Application of the principles of strength of materials to the analysis and design of machine parts. Curved bars, multi-support shafts, torsion, cylinders under pressure, thermal stresses, creep, and relaxation, rotating disks and other machine elements are considered. Fall and spring terms annually. 3 credit hours

MANE-4170 Machine Dynamics
The principles of dynamics as applied to the analysis of the accelerations and dynamic forces in machines and machine components such as linkages, cams, and gears.
The effect these dynamic forces have on the dynamic balance and operation of the machines and the attending stresses in the individual components of the machines. Prerequisites: ENGR-2090 and MATH-2400. Spring term annually. 3 credit hours

MANE-4180 Mechanisms
The displacement, velocity, and acceleration analysis of planar mechanisms, four bar linkages, slider, cranks, cams, and gear systems. Some synthesis techniques. Explore the use of existing large and small computer graphics programs. Prerequisite: ENGR-2090. Spring term annually. 3 credit hours

MANE-4200 Rotorcraft Performance, Stability, and Control
Topics in flight dynamics generic to rotorcraft (e.g., helicopters and tilt-rotor VTOLs). Lift and propulsion systems, hovering and forward flight characteristics. Dynamics of flapping rotors. Longitudinal and lateral trim. Dynamic flight stability, controllability, and basics of automatic control requirements. Prerequisite: MANE-4070 or equivalent. Fall term annually. 4 credit hours

MANE-4230 Fixed-Wing Aircraft Design
Conceptual and preliminary design of a fixed-wing aircraft to satisfy given commercial aircraft specifications. Includes elements of initial sizing and weights, geometry selection, aerodynamic design, propulsion integration, stability and control, loads, structural design, manufacturability, and cost analysis. Writing-intensive assignments help develop communication skills. Prerequisites: MANE-4060 and MANE-4070. Spring term annually. 3 credit hours

MANE-4240 Introduction to Finite Elements
An introductory course in use of the Finite Element Method (FEM) to solve one- and two-dimensional problems in fluid mechanics, heat transfer, and elasticity. The methods are developed using weighted residuals. Algorithms for the construction and solution of the governing equations are also covered. Students will be exposed to the use of commercial finite element software. (Cross listed as CIVL-4240. Students cannot obtain credit for both this course and CIVL-4240.) Prerequisites: ENGR-2250 or ENGR-2530 or ECSE-4160 and senior standing. Fall and spring terms annually. 3 credit hours

MANE-4250 Mechatronic System Design
Mechatronic system design principles, modeling/analysis/control (continuous and digital) of dynamic systems, control sensors/actuators and microcomputer/microcontroller interfacing, control electronics, and real-time programming for control. Lectures and weekly homework exercises; student teams complete two projects, each with required oral and written presentations; reverse engineering of a successful mechatronic system and a design-build-test exercise based on one of the laboratory systems of Mechatronics. Prerequisite: MANE-4490. Spring term annually. 3 credit hours

MANE-4260 Design of Mechanical Systems
This course acquaints students with all the phases of the design process from recognizing the need through a detailed conceptual design. Students work in teams on a semester-long project with the assistance of faculty consultants. Design techniques are presented in lecture. The design projects require students to draw upon their engineering background, experience, and other pertinent resources. Oral and written presentations are required. Writing-intensive assignments help develop communication skills. Prerequisite: MANE-4030. Fall and spring terms annually. 4 credit hours

MANE-4270 Dynamics and Control of Multibody Systems
Dynamic analysis and control of multibody mechanical systems. Review of dynamic analysis using Newton-Euler and Lagrange formulations of equations of motion. Introduction to dynamic analysis using Kane’s Method. Comparison of the methods for formulating equations of motion. Computer-aided control system analysis and design using root-locus, frequency-response, and state-space analysis and design methods. Introduction to linear quadratic control and robust/H control. Prerequisites: ENGR-4050, MANE-4170. Offered on availability of faculty. 3 credit hours

MANE-4280 Design Optimization: Theory and Practice
This course introduces the student to the theory and use of numerical design optimization methods, with a major focus on the algorithms and problem formulations relevant to engineering design. The lectures concentrate on the algorithm development while the exercises emphasize correct problem formulation and evaluation of the results. Topics include methods for unconstrained nonlinear problems, constrained linear and nonlinear problems, sensitivity analysis, multiobjective optimization, and mechanism optimization. Prerequisites: MANE-4030 or equivalent. Fall term annually. 3 credit hours

MANE-4290 Electronic Packaging
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as ECSE-4290 and MTLE-4290. Students cannot obtain credit for both this course and either ECSE-4290 or MTLE-4290.) Prerequisites: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. Fall term annually. 3 credit hours

MANE-4330 Analytical Methods in Solid Mechanics I
Vectors, tensors, indicial and invariant notation, orthogonal
curvilinear coordinates, integral theorems. Infinitesimal strain tensor. Conservation equations, stress tensor, equations of motion, boundary conditions. Variational procedures. Anisotropic and isotropic linear elastic constitutive equations. Elementary waves and vibrations in linear elastic solids. Prerequisites: ENGR-2530, MATH-2400 or equivalent. Fall term annually. 3 credit hours

MANE-4350 Nuclear Instrumentation and Measurement
Instrumentation and systems for the collection and processing of engineering data. Principles and operation of transducers and sensors, radiation detectors, optics, lasers, imaging techniques. Signal processing and data collection. Prerequisite: ENGR-2830 or equivalent. Fall term annually. 3 credit hours

MANE-4360 Introduction to Fusion Devices and Systems
Examination of the requirements and approaches for the commercial application of nuclear fusion. Discussion of fusion basics including fusion reactions, competing processes, energy balances, the need for plasmas, plasma confinement, and heating concepts. Analyzes of fusion reactor embodiments based on magnetic and inertial confinement concepts. Identification of key physics, engineering, and technology issues associated with fusion development. Consideration of economics, environmental, and resource implications of fusion energy systems. Prerequisite: permission of instructor. Fall term annually. 3 credit hours

MANE-4370 Nuclear Engineering and Engineering Physics Laboratory
A laboratory course covering topics in instrumentation, computer-controlled instrument interfacing and data acquisition, electronics (simple circuits, signal analysis and Fourier Transforms), applied physics, optical interferometry, laser-doppler interferometry, multiphase flow, fluid dynamics, and alpha spectroscopy. Error analyses are emphasized. Lab attendance is required along with formal written lab reports, which include data error analysis. Prerequisites: ENGR-2600 and ENGR-2830. Fall term annually. 4 credit hours

MANE-4380 NEEP Senior Design Project I
This is the first of a two-semester sequence for seniors intended to be a “capstone” design project where students have the opportunity to utilize the broad range of their undergraduate experience in an interdisciplinary design project. Projects are selected to provide interaction between nuclear engineering and engineering physics majors to provide exposure to cross-fertilization of ideas and team interaction, which simulates anticipated future professional experience. The product of each design project is a comprehensive report or design proposal having both global and detail completeness. Under some circumstances, the project may involve development of cost information necessary to effect construction and may actually involve construction and commissioning of the designed apparatus. This is a writing-intensive course. Prerequisite: permission of instructor. Fall term annually. 1 credit hour

MANE-4390 NEEP Senior Design Project II
This is a required continuation of MANE-4380. Spring term annually. 2 credit hours

MANE-4400 Nuclear Power Systems Engineering
Application of thermodynamics, heat transfer, and fluid flow principles to nuclear energy generation systems, including nuclear reactors, nuclear fusion devices and systems, and radiation technology. Engineering aspects of 1st and 2nd Laws of Thermodynamics will be emphasized. Characteristics and safety aspects of nuclear power equipment will be discussed. Prerequisite: ENGR-2250. Spring term annually. 4 credit hours

MANE-4410 Applied Atomic and Nuclear Physics
Review of atomic and nuclear physics and quantum mechanics; application to atomic, molecular and nuclear systems; particle and photon emissions; photon/particle interactions; quantum statistics; field theory of electricity and magnetism; Maxwell equations in free space and within materials; applications to semiconductors, superconductors, accelerators, fusion systems, nuclear reactors; key measurements and databases. Prerequisites: ENGR-2830 or equivalent. Fall term annually. 4 credit hours

MANE-4420 Radiation Technology
An introductory course on the generation, distribution, and interaction of ionizing radiation. Radiation sources such as radioisotopes, accelerators, focused ion beams, and cosmic rays are studied. Applications to semiconductor electronic devices, chemical polymerization, food preservation, sterilization, material modification, industrial and medical radiography, and radiation damage are presented. Prerequisite: ENGR-2830. Fall term annually. 3 credit hours

MANE-4430 Fundamentals of Gas-Liquid, Two-Phase Flow
Theory of systems involving two-phase flow of liquids and gases or vapors: flow regimes including bubbly, slug annular, and droplet, and combinations, homogeneous, separated, or dispersed flows are introduced. Single-phase flows modeling concepts and modeling methods based on the drift-flux model, and the two-fluid model are utilized in the analysis of gas-liquid flow behavior. Prerequisites: ENGR-2250 and either MATH-4600 or permission of instructor. Fall term annually. 3 credit hours

MANE-4440 Critical Reactor Laboratory
Theory and operation of a low-power critical reactor facility: reactor layout, instrumentation, shielding, controls,
hazards, problems of start-up and shutdown, and operating parameters. Approach to criticality, operating procedures, kinetics. Measurements are made of neutron flux, fuel rod worth, radiation, and various reactivity effects. Prerequisite: MANE-4480. Spring term annually.  

3 credit hours

MANE-4450 Nuclear Fuel Management

3 credit hours

MANE-4460 Nuclear Power Plant Operations

3 credit hours

MANE-4470 Radiological Engineering
Background radiation, biological effects of radiation, radiation units and measurements, analysis of radiation exposures, dosimetry, shielding calculations, nuclear safety. A lecture and laboratory course that covers radiation survey techniques and measurements. Prerequisite: ENGR-2830 or equivalent. Spring term annually.  

4 credit hours, 6 contact hours

MANE-4480 Physics of Nuclear Reactors
Basic nuclear reactor theory; fuel cycles. Neutron diffusion and slowing down; criticality analyses for homogeneous and heterogeneous systems; reactor kinetics and control; reactivity coefficients; fuel management. Reactor systems and types; reactor design. Power plant safety. Prerequisite: MANE-2400 or equivalent. Spring term annually.  

4 credit hours

MANE-4490 Mechatronics
The synergistic combination of mechanical engineering, electronics, control engineering, and computer science in the design process. The key areas of mechatronics studied in depth are control sensors and actuators, interfacing sensors and actuators to a microcomputer, discrete controller design, and real-time programming for control using the C programming language. The unifying theme for this heavily laboratory-based course is the integration of the key areas into a successful mechatronic design. Prerequisites: ENGR-2350, ENGR-4650, and senior standing. Fall term annually.  

3 credit hours, 5 contact hours

MANE-4550 Analysis of Manufacturing Processes
Review of basic aspects of manufacturing engineering including driving forces, quality attributes, tolerances, etc. Examination of basic principles of mechanics, engineering materials, analysis of both bulk-forming ( forging, extrusion, rolling, etc. ) and sheet- forming processes, metal cutting, and other related manufacturing processes. Discussion and role of computer-aided manufacturing in these areas. Prerequisites: ENGR-2530 and MANE-4030. Spring term annually.  

3 credit hours

MANE-4610 Vibrations

3 credit hours

MANE-4650 Fracture Mechanics

3 credit hours

MANE-4670 Mechanical Behavior of Materials I
Mechanical behavior of materials and its influence on design applications. Topics include simple mechanical behavior (tension, compression, etc.), combined stress effects on deformation and fracture, ductile fracture, fracture toughness, creep behavior, fatigue, damping, and internal friction. Prerequisite: ENGR-2530. Fall term annually.  

3 credit hours

MANE-4700 Solar Devices and Renewable Energy
Solar irradiation, its nature, and its measurement. Insolation on tilted surfaces. Application of the principles of heat transfer and thermodynamics to the theoretical and experimental analysis of solar energy components used in the heating and cooling of buildings as well as hot water heating devices. Theoretical consideration of thermal storage devices, solar collectors, and solar-augmented heat pumps. Approximate techniques; other ongoing research topics. Open to juniors and above. Spring term annually.  

3 credit hours

MANE-4710 Advanced Heat Transfer
Comprehensive treatment of conduction, convection (including boiling and condensation), and radiation heat transfer. Thermal system design and performance (including heat exchangers). Emphasis is on physical and mathematical modeling of engineering systems for application of modern analytical and computational solution methods. Prerequisite: MANE-4010 or equivalent. Fall term annually.  

3 credit hours
MANE-4720 Design and Analysis of Energy Systems
This course applies basic concepts of fluid mechanics and heat transfer to a wide variety of energy system components such as heat exchangers, pumps, fans, and bearings. Design and analysis techniques including modeling and simulation methods are developed for energy systems such as piping networks and refrigeration units. Prerequisite: MANE-4010. Spring term annually. 3 credit hours

MANE-4750 Combustion Systems
Introduction to elementary theory of combustion and applications to energy sources, fires, and explosions. Discussion of internal and external combustion piston and turbine engines, solid- and liquid-propellant rockets, fire and explosion hazards of gaseous fuels, propellant and explosive performance. Prerequisite: MANE-4010 or equivalent. Fall term annually. 3 credit hours

MANE-4760 Heating, Ventilation, and Air Conditioning
Principles for the control of air properties to meet comfort and industrial requirements, load determination, psychrometry, cycles, transmission, distribution, and automatic control. Prerequisite or corequisite: MANE-4010. Fall term annually. 3 credit hours

MANE-4800 Boundary Layers and Heat Transfer
The Navier-Stokes equations and the boundary layer approximation. Exact solutions and integral methods of incompressible boundary layers. Transition; turbulence. Convective heat transfer in laminar and turbulent flow. Prerequisite: MANE-4070 or MANE-4010. Fall term annually. 3 credit hours

MANE-4830 Acoustics Engineering
Solutions of acoustic wave and diffusion equations; stationary and moving monopole, dipole, quadrupole sources; geometrical acoustics; acoustical impedance, energy density, source strength, intensity flux; near and far field approximations; stationary and moving boundary interaction (viscous, dilational boundary layers, streaming, scattering). Applications include propeller, turbulent noise; total- and semi-anechoic chambers; loudspeakers; microphones, straight, tapered fluidic transmission lines; water hammer; musical instruments; room acoustics; sound absorbing, transmitting, and reflecting solid, liquid, gaseous media property determination. Prerequisites: ENGR-2090 and MATH-2400. Spring term alternate years. 3 credit hours

MANE-4860 Introduction to Helicopter Design
Aerodynamics and dynamics of lifting rotors. Design concepts by which rotor weight and stress are minimized and vehicle control is provided. Weight and engine power trends for configuration definition. Center of gravity and aerodynamic lift and moment for equilibrium and desired aircraft attitude. Methods for determining size, weight, and cost for a given payload, useful volume, and specified performance. Writing-intensive assignments help develop communication skills. Prerequisites: ENGR-2250 and MATH-2400. Spring term annually. 3 credit hours

MANE-4880 Analysis of Engineering Problems
An advanced course in mechanical engineering principles applied to practical engineering problems and systems. Topics vary and may include heat transfer, thermodynamics, rigid-body dynamics, fluid mechanics, and design synthesis. Complex variables and probability and statistics are also covered and applied to practical problems. A weekly project is required, with an oral or written presentation. GE/RPI students only. Prerequisite: ECSE-4470. Spring term annually. 3 credit hours

MANE-4900 Aeroelasticity and Structural Vibrations
Basic concepts in static and dynamic aeroelasticity. Divergence and control surface effectiveness, using section models. Structural vibrations, free and forced motion of discrete and continuous structures, introduction to modal analysis. Aeroelastic behavior of complex structures, dynamic aeroelasticity. The role of numerical methods will be emphasized. Prerequisites: MATH-2400, MANE-2060 and MANE-4060 or equivalent. Spring term annually. 3 credit hours

MANE-4910 Fluid Dynamics Laboratory
Laboratory experiments with primary emphasis on flow studies using subsonic and supersonic wind tunnels and shock tubes. Hot-wire anemometry and laser-Doppler velocimetry. Corequisite: MANE-4080. Fall term annually. 2 credit hours

MANE-4920 Aeronautical Structures and Control Laboratory
Laboratory experiments with primary emphasis on lightweight structures, structural dynamics, and control as it applies to aircraft and spacecraft. Experiments include elastic instability, linear and nonlinear structural vibrations, gyrodynamics, spacecraft stability, etc. Prerequisite: MANE-4060. Spring term annually. 2 credit hours
MANE-4940 Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Prerequisite: permission of instructor. Fall and spring terms annually. 3 to 6 credit hours

MANE-4960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Fall and spring terms annually. 3 credit hours

MANE-6060 Rotorcraft Performance, Stability, and Control
Topics in flight dynamics, generic to rotorcraft. Lift and propulsion system, hovering, forward flight. Longitudinal and lateral trim. Dynamic stability. Corequisite: ENGR-4050. Fall term annually. 3 credit hours

MANE-6070 Aerodynamics of Rotors
Momentum, blade element, vortex, and cascade theories. Nonuniform inflow; rigid and nonrigid wakes; rotating and fixed system interactions; steady and nonsteady flow. Static thrust (hover), axial flow (rotor ascent and descent, propeller forward flight), cross flow (rotor forward flight, propeller yaw) flight conditions. Prerequisites: MANE-4070 or equivalent. Offered on sufficient demand. 3 credit hours

MANE-6110 Kinematic Synthesis
Analytical and geometrical theories of function, path, and motion generation of four bar linkages. Consists of 3, 4, and 5 accuracy points. Review of recent developments and use of computer graphic methods. Spring term annually. 3 credit hours

MANE-6120 Robotics
Elements of robot manipulators, mobility criteria, 3-D coordinate systems, matrix representation. Joint solutions and motion characteristics. Simulation on computer graphics. Hands-on experience of several robots and applications in industry. Offered on sufficient demand. 3 credit hours

MANE-6130 Dynamics of Rotating Machinery
Analytical basis of design for rotating machinery mounted on various types of bearing supports, as exemplified by turboshaft engines, centrifugal or axial flow compressors, vehicle drivetrains, etc. Description of analytical and numerical tools for evaluation of dynamic stability, critical speeds, and unbalance response of rotor-bearing systems. Special problems encountered in modern applications operating through and above the critical speeds, and means of their solution, including rigid and flexible rotor balancing and support damper design. Several informal laboratory sessions are included to enhance visualization of rotordynamic phenomena. Seniors and graduate students only. Prerequisite: MANE-4170. Offered on availability of faculty. 3 credit hours

MANE-6150 Advanced Structural Analysis
Development and application of the variational formulation to structural dynamics problems involving effects such as rotary inertia, shear deformation, extensionality, and nonlinearities. Several papers published in the technical journals are also discussed during the semester. Offered on availability of faculty. 3 credit hours

MANE-6160 Advanced Design with Composites
Advanced topics in structural design with continuous-fiber advanced composites. Development of plate equations including interlaminar stresses. Introduction to and use of constrained numerical optimization program. Statistical effects on failure. Saint Venant’s principle for anisotropic materials. Failure criteria, including stress concentration effects. Plate and shell buckling. A detailed student design project is assigned. Prerequisite: MANE-4130 or permission of instructor. Spring term annually. 3 credit hours

MANE-6170 Mechanics of Solids
Introduction to Cartesian tensors, infinitesimal strain kinematics, equations of motion. Models of material behavior: isothermal linear isotropic and anisotropic elasticity, thermoelasticity, linear viscoelasticity, and rate-independent plasticity. General principles in elasticity: minimum potential and complementary energy, reciprocal theorem. Formulation of linear elastic boundary value problems, methods of solutions for 2-D and 3-D elasticity problems. Correspondence principle of linear viscoelasticity, applications to simple structural components. Use of symbolic computations in the solution of BVP. (Cross listed as CIVL-6170. Students cannot obtain credit for both this course and CIVL-6170.) Spring term annually. 3 credit hours

MANE-6180 Mechanics of Composite Materials
Mechanics of elastic heterogeneous solids. Plasticity of composite materials. Thermoelastic and thermoplastic behavior. Mechanics of distributed damage. Mechanical behavior. (Cross listed as CIVL-6180. Students cannot obtain credit for both this course and CIVL-6180.) Prerequisite: one graduate course in mechanics of solids. Fall term annually. 3 credit hours

MANE-6200 Plates and Shells
Preliminaries on linear, three-dimensional elasticity theory. Reduction of the elasticity theory to theories of plates and shells. Anisotropy, Nonlinear theories. Applications. (Cross listed as CIVL-6200. Students cannot obtain credit for both this course and CIVL-6200.) Annually. 3 credit hours

MANE-6210 Structural Stability
Indicial and invariant notation, elements of variational calculus and nonlinear elasticity. Variational derivation of the linear stability equations for plates, rods, open thin-walled sections and cylindrical shells. Solutions of stability problems in each of these systems and development of approx-
MANE-6220 Thermal Stresses
The coupled linear thermoelastic and generalized heat equations, as derived from irreversible thermodynamics. Solutions in terms of Boussinesq-Papkovitch potentials. Reduction of thermoelastic problems to isothermal elastic problems. Steady state and transient elastic, anelastic, and viscoelastic thermal-stress analysis. Offered on sufficient demand.

3 credit hours

MANE-6240 Introduction to Neural Networks
Neural networks are program and memory at once, useful where traditional techniques fail, i.e., for artificial speech and image recognition. Emphasis on existing and emerging engineering applications. Parallel distributed processing, Hebb's rule, Hopfield net, back-propagation algorithm, perceptrons, unsupervised learning, Kohonen self-organizing map, genetic algorithms, neocognitron, adaline. Illustrated with computer programs and lectures. (Cross-listed as DSES-6870. Students cannot obtain credit for both this course and DSES-6870.) Fall term alternate years.

3 credit hours

MANE-6250 Continuum Mechanics

3 credit hours

MANE-6260 Applications in Linear Elasticity

3 credit hours

MANE-6270 Environmental Radiation Safety Controls
Consideration and control of the health hazards peculiar to the atomic industry. Radiological units; exposure control; shielding; fallout; toxic materials; shipping and storage; waste disposal; legal aspects. Introduction to criticality hazards. Nonionizing radiation. Prerequisites: MANE-2400 or equivalent. Offered on availability of faculty.

4 credit hours

MANE-6280 Nuclear Reactor Analysis II

3 credit hours

MANE-6290 Radiation Transport Methods

3 credit hours

MANE-6300 Numerical Methods in Reactor Analysis
Difference equations; matrix operation, linear systems, matrix eigenvalue problems, multi-group diffusion, and transport theory methods. Sn calculations, Monte Carlo methods. Application to nuclear engineering calculations, such as flux and power distributions, heat conduction, programming reactor problems for digital computers, codes, etc. Prerequisites: MANE-4480, MATH-4600 or equivalent. Fall term alternate years.

3 credit hours

MANE-6310 Reactor Design
The reactor design problem is studied using current methods. Emphasis is placed on thermal and hydraulic analyses of power reactors, neutronics, fuel cycles, economics, nuclear analysis, control, siting, and safety. Complete reactor systems are analyzed. Standard reactor design codes are utilized. Prerequisites: MANE-2400 (may be concurrent). Spring term alternate years.

3 credit hours

MANE-6320 Radioactive Waste Management

3 credit hours
MANE-6350 Radiation Shielding

MANE-6360 Reactor Reliability and Safety
Theory and applications of reliability and risk assessment. Boolean algebra, logic diagrams, redundancy, and majority-vote configurations. System synthesis by reliability and fault tree techniques, quantitative evaluation, uncertainty analysis. Common cause events, failure data, and failure models. Allocation of risk to subsystems. Availability, repair policies, renewal theory. Operational reliability methods. Prerequisites: ENGR-4050 and MATH-4600. Offered on availability of faculty. 3 credit hours

MANE-6370 Thermal-Hydraulic Design of Nuclear Reactors
An introduction to the principles underlying the thermal-hydraulic design of nuclear power reactors. Topics include plant thermal limits, sub-channel analysis, thermal-hydraulic stability analysis, and reactor system response during both normal and postulated accident conditions. Prerequisite: MANE-6840 or equivalent. Offered on availability of faculty. 3 credit hours

MANE-6380 Nuclear Reactor Materials
The physical metallurgy and associated physical chemistry of problems encountered in the application of materials in nuclear reactors is discussed. Specifically, the metallurgy and physical chemistry of ceramic fuels (e.g., oxygen potentials), the primary fuel densification and pellet-clad interaction mechanisms, irradiation-induced creep, hardening, and embrittlement mechanisms, and the properties of zircaloy are covered. Prerequisites: MANE-4480. Offered on availability of faculty. 3 credit hours

MANE-6390 Atomic and Nuclear Physics Applications
Principles and design of spectrometers and accelerators; NMR, ESR, Mossbauer methods, lasers, microwave devices, and combinations of these; sources, beam transport and focusing; targets and effects. Prerequisite: MANE-4410. Spring term alternate years. 3 credit hours

MANE-6400 Analytical Dynamics
A fundamental course in dynamics of rigid and flexible bodies. Review of kinematics and Newtonian dynamics; virtual variations and fundamentals of calculus of variations; generalized coordinates, velocities and momenta; constraints; generalized Hamilton's principle and Lagrangean dynamics; rotational dynamics, orientation angles and Euler parameters; brief introduction to the analysis of nonlinear systems and stability of motion. Applications to the motion of rigid and flexible bodies. The role of symbolic manipulation in dynamics is introduced. Fall term annually. 3 credit hours

MANE-6410 Celestial Mechanics
Introduction to celestial mechanics, orbits, and perturbations, exterior ballistics, powered flight trajectories, space flight trajectories. Offered on sufficient demand. 3 credit hours

MANE-6420 Multibody Dynamics
Analytical and numerical analysis of dynamic behavior of multibody mechanical systems. Emphasis on understanding all aspects of modeling and analysis process associated with real (spacecraft, automotive, biomechanical, etc.) systems. Review of traditional dynamic analysis methods (Newtonian-Euler, Lagrange, etc.), presentation of more efficient, powerful, recently developed methods (including Kane's method). Comparison of the different formulations and their applicability to computer simulation. Treatment of constraints, extraction of data from equations of motion, and computational issues. Spring term alternate years. 3 credit hours

MANE-6430 Nonlinear Vibrations
A fundamental course in nonlinear vibrations and stability. Basic concepts about linear and nonlinear systems; Routh-Hurwitz and Liapunov's stability criteria; systems with periodic coefficients and Floquet theory; effects of nonlinearities; limit cycles, jump, saturation, nonlinear resonances, modal energy exchange, etc.; perturbation methods: straightforward perturbations, Lindstedt-Poincare, harmonic balancing, multiple time scales; steady-state and transient responses of nonlinear systems. Applications to discrete and structural systems. Use of symbolic manipulation to analyze problems. Spring term annually. 3 credit hours

MANE-6450 Mechanics of Materials Processing
Modeling and analysis of common manufacturing processes. Topics include bulk-forming, sheet-forming, and casting processes. Classical analysis techniques, upper bound analysis, slip-line field theory, asymptotic methods, and the finite element method are investigated. Prerequisite: MANE-4330 or MANE-6170 or equivalent. Offered on sufficient demand. 3 credit hours

MANE-6460 Mechanical Behavior of Materials II
Failure of structural materials under cyclic stress. Topics include historical review, low cycle fatigue, role of cyclic plastic strain, mean stress, notch behavior, fatigue crack initiation and propagation, fracture mechanics approaches, J-Integral and short crack problems, environment, elevated temperature, testing methods. Spring term annually. 3 credit hours
MANE-6480 Health Physics and Medical Aspects of Radiation
Use of radioisotopes and radiation in nuclear medicine, radiation chemistry, basis of dosimetry, ionizing and non-ionizing energy transfer processes in living tissue and cells. Radiation effects on the structure of nucleic acids, proteins, and cell membranes with emphasis on mechanisms by which cell viability is lost. Background in radiation chemistry is developed in particular for engineering majors. Applications are given in nuclear medicine, cancer therapy, and radiation in the environment. Fall term alternate years. 3 credit hours

MANE-6490 Plasticity
Stress invariants. Polychoric stress-strain relation for strain hardening materials. Ideal plasticity, various yield conditions and associated flow rules. Variational principles. Limit analysis. Applications in elastic-plastic stress analysis, metal forming, plastic collapse, and plastic instability. Fall term annually. 3 credit hours

MANE-6500 Non-Newtonian Fluid Mechanics
Flow of non-Newtonian fluids such as polymeric liquids, granular mixtures, etc. Flow phenomena and material functions. Integral and differential constitutive equations for generalized Newtonian, linear viscoelastic, and ordered fluids. Offered on sufficient demand. 3 credit hours

MANE-6520 Advanced Topics in Two-Phase Flow
Treatment of advanced topics encountered in two-phase flow, including averaging of conservation equations, interfacial transport and constitutive equations, virtual mass effects, matrix formulation of two fluid modeling, well posedness, drift flux modeling and transient analysis, dynamic and continuity waves and flooding phenomena, stability analysis of two-phase systems, numerical techniques, and two-phase flow instrumentation. Prerequisite: MANE-6580. Spring term alternate years. 3 credit hours

MANE-6530 Turbulence
Navier-Stokes equations, linear stability, vorticity and its origin, transition in wall-bounded and free-shear flows, statistics and Reynolds averaging, homogeneous turbulence, coherent structures, laboratory methods for study of turbulence, including turbulence measurements and turbulence modeling. Prerequisite: MANE-4800 or MANE-4110 or equivalent. Spring term annually. 3 credit hours

MANE-6540 Advanced Thermodynamics
General principles and applications of equilibrium thermodynamics. Second law analysis of energy systems. Thermodynamic relations, equations of state, properties of single and multiphase systems. Elementary statistical thermodynamics. Fundamentals of nonequilibrium thermodynamics. Annually. 3 credit hours

MANE-6550 Theory of Compressible Flow
General equations of compressible flow. Specialization to inviscid flows in two space dimensions. Linearized solutions in subsonic and supersonic flow. Characteristic equations for supersonic flow with applications in external and internal flow. One-dimensional nonsteady compressible flow. Introduction to transonic flow. Prerequisite: MANE-4070 or equivalent. Fall term annually. 3 credit hours

MANE-6580 Gas Dynamics
Properties of gases at high temperatures; thermodynamics and chemical kinetics. Macroscopic description of high-speed flows of chemically reacting and ionized gases. Shock tube theory and applications. Reentry aerodynamics. The interaction of high-speed plasma flows with electromagnetic fields. Prerequisite: permission of instructor. Offered on availability of faculty. 3 credit hours

MANE-6610 Transonic Aerodynamics
Introduction to the equations of inviscid compressible flow; expansion procedure for airfoils in transonic flow and the Karman-Guderley equation; transonic-shock jump relations; the hodograph equations for transonic flow, with elementary applications; lift and drag integrals; transonic far fields; axially symmetric flow. Prerequisite: MANE-6550 or equivalent. Spring term alternate years. 3 credit hours

MANE-6630 Conduction Heat Transfer
An introduction to the mathematics of conduction heat transfer. Applications of results illustrated by examples from furnace design, cooling of electric components, building design, heat exchanger design. Fall term annually. 3 credit hours

MANE-6640 Radiation Heat Transfer
An introduction to radiation heat transfer in diathermanous media and participating media. Selected applications from spacecraft design, furnace design, meteorology, temperature measurement, environmental control. Annually. 3 credit hours

MANE-6650 Convective Heat Transfer
Fundamental study of convection heat transfer in laminar and turbulent internal and external flows. Unsteady flows, combined heat and mass transfer, conjugated unsteady heat transfer, and buoyancy induced convection. Selected applications from aeronautics and heat exchanger design. Prerequisite: MANE-4800 or equivalent. Spring term annually. 3 credit hours

MANE-6660 Fundamentals of Finite Elements
Graduate-level course on the fundamental concepts and technologies underlying finite element methods for the numerical solution of continuum problems. The course emphasizes the construction of integral weak forms for elliptic partial differential equations and the construction of the elemental level matrices using multi-dimensional shape
functions, element level mappings, and numerical integration. The basic convergence properties of the finite element method will be given. This course serves as preparation for students working on finite element methods. (Cross listed as CIVL-6660. Students cannot obtain credit for both this course and CIVL-6660.) Prerequisite: MATH-2400 or equivalent. Fall term annually. 3 credit hours

MANE-6670 Nonlinear Finite Element Methods
The formulations and solution strategies for finite element analysis of nonlinear problems are developed. Topics include the sources of nonlinear behavior (geometric, constitutive, boundary condition), derivation of the governing equations for nonlinear systems such as large displacement, nonlinear elasticity, rate independent and dependent plasticity and other nonlinear constitutive laws, solution strategies for nonlinear problems (e.g., incrementation, iteration), and computational procedures for large systems of nonlinear algebraic equations. (Cross listed as CIVL-6670. Students cannot obtain credit for both this course and CIVL-6670.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years. 3 credit hours

MANE-6680 Finite Element Programming
Examines the implementation of finite element methods. Consideration is first given to the techniques used in classic finite element programs. Attention then focuses on development of a general geometry-based code which effectively supports higher order adaptive technique. Technical areas covered include: effective construction of element matrices for p-version finite elements, ordering of unknowns, automatic mesh generation, adaptive mesh improvement, program and database structures. Implementation of automated adaptive techniques on parallel computers is also considered. (Cross listed as CIVL-6680. Students cannot obtain credit for both this course and CIVL-6680.) Prerequisite: CIVL-6660, MANE-6660, CSCI-6860 or MATH-6860. Spring term odd-numbered years. 3 credit hours

MANE-6690 Advanced Finite Element Formulations
This course focuses on generalized weighted residual methods and multi-field variational principles for constructing approximate solutions to sets of governing differential equations and associated boundary conditions. Topics include hybrid and mixed methods, boundary element formulations, p-version finite elements, global/local procedures, and penalty methods. Problem areas include solid mechanics (nearly incompressible solids, plates, and shells), fluid mechanics including compressible flows, and heat transfer. (Cross listed as CIVL-6690. Students cannot obtain credit for both this course and CIVL-6690.) Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years. 3 credit hours

MANE-6700 Finite Element Methods in Structural Dynamics
Solutions to the free vibration and transient dynamic responses of two- and three-dimensional structures by the finite element method are considered. The governing finite element matrix equations are derived and numerical aspects of solving these time-dependent equations considered. Topics include the formulation of the eigenvalue problem, algorithms for eigenvalue extraction, time integration methods including stability and accuracy analysis, and finite elements in time. Modal analysis and direct time integration techniques are compared for a variety of two- and three-dimensional problems. (Cross listed as CIVL-6700. Students cannot obtain credit for both this course and CIVL-6700.) Prerequisite: CIVL-6660 or MANE-6660. Fall term odd-numbered years. 3 credit hours

MANE-6710 Design and Simulation of Experiments in Heat and Mass Transfer
This graduate course provides interactive, hands-on learning of experimental techniques, finite element modeling, and fundamentals of fluid mechanics and heat transfer. Topics include analogy between heat, mass, and momentum transfer. Dimensional analysis. Steady state and transient techniques for property measurements. Errors. Heat transfer coefficients in forced and free convection. Shear stress and friction coefficients on the flat plate. Enclosures. Prerequisites: MANE-6630 and MANE-6650, or equivalent. Fall term annually. 3 credit hours

MANE-6720 Computational Fluid Dynamics
Course focuses on computational approaches to solve the Navier-Stokes equations. Course assumes knowledge of numerical methods and therefore directly attacks the obstacles to applying these methods to the Navier-Stokes equations. Issues concerning implementation of finite difference methods (FDM), finite volume methods (FVM) and finite element methods (FEM) will be discussed. These issues include: the discrete formulation, nonlinear equation iteration (steady)/marcher (time-accurate), linear equation formation, boundary condition prescription and linear equation solution. Prerequisite: MANE-6660 or equivalent. Spring term even-numbered years. 3 credit hours

MANE-6730 Tribology
A basic course in tribology that covers both the fundamental and applied aspects of the subject. Content includes viscometry, the Reynolds equation, thrust and journal bearings (including design), thermal effects, dynamic loading and instability of bearings, rolling contact bearings, dry bearings, and theories of wear. This course includes design principles and data and is basic to other courses offered in tribology. Restricted to graduate students. Fall term odd-numbered years. 3 credit hours
MANE-6740 Advanced Topics in Tribology
A course for students already versed in the basic concepts of hydrodynamic lubrication. Advanced topics of current interest in the field are stressed. Material may be drawn from the literature and taught by experts in the particular field. Recent areas covered include elastohydrodynamic lubrication, bearing and rotor dynamics, inertia and turbulence effects. Restricted to graduate students. Prerequisite: MANE-6730 or permission of instructor. Spring term annually.  

3 credit hours

MANE-6760 Finite Element Methods for Fluid Dynamics
Analysis of finite element methods for basic classes of problems in fluid mechanics. Starting with scalar transport equations and building to compressible and incompressible Navier-Stokes equations. Emphasis on developing and analyzing formulations that are stable and higher-order accurate such as Galerkin/least-squares methods and SUPG methods. Unsteady formulations are proposed using space-time methods and semi-discrete methods. Prerequisite: MANE-6660. Spring term odd-numbered years.  

3 credit hours

MANE-6780 Numerical Modeling of Failure Processes in Materials
State of the art in computational modeling of failure processes in materials. Topics include numerical modeling of discrete defects, distributed damage and multiscale computational techniques including multiple scale perturbation techniques, boundary layer techniques, and various global-local approaches. (Cross listed as CIVL-6780. Students cannot obtain credit for both this course and CIVL-6780). Prerequisite: CIVL-6660 or MANE-6660. Spring term even-numbered years.  

3 credit hours

MANE-6790 Mathematical Applications in Nuclear Engineering and Engineering Physics
Advanced methods of mathematics with applications to problems relating to a broad range of mathematical physics such as required for analysis of fluid mechanics, heat transfer, nuclear reactions, bending and vibrations, wave motions. Ordinary and partial differential equations, Laplace transforms, series solutions, boundary value problems, vector analysis, higher-dimensional calculus, complex variables. Prerequisite: MATH-2400. Spring term annually.  

3 credit hours

MANE-6800 Manufacturing Systems Integration
Examination of the basic elements that are used to integrate the design and manufacture of capital and consumer products; manufacturing information systems, CAD/CAM systems, and manufacturability considerations when integrating unit process operations. Fall term annually.  

3 credit hours

MANE-6810 Advanced Manufacturing Methods
Some of the basic principles and recent developments in advanced manufacturing processes and methods will be covered. Basics of mechanics of materials and plasticity theory will be covered initially. Areas of manufacturing to be examined are Part Description, Primary Forming, Secondary Forming, and Finish Machining. Examples of these areas are to be given and follow a selected and logical sequence of design and manufacturing. Spring term annually.  

3 credit hours

MANE-6820 Finite Deformation Plasticity: Theory and Applications

3 credit hours

MANE-6830 Combustion
Review of fundamentals of thermodynamics, chemical kinetics, fluid mechanics, and modern diagnostics. Discussion of flame propagation, thermal and chain explosions, stirred reactors, detonations, droplet combustion, and turbulent jet flames. Introduction to computational tools for complex equilibrium and kinetic calculations. Application to problems such as pollutant formation. (Cross listed as CHME-6830. Students cannot obtain credit for both this course and CHME-6830). Prerequisite: permission of instructor. Spring term odd-numbered years.  

3 credit hours

MANE-6840 An Introduction to Multiphase Flow and Heat Transfer I
This course is intended to give students a state-of-the-art understanding about single and multicomponent boiling and condensation heat transfer phenomena. Applications include the analysis of nuclear reactors, oil wells, and chemical process equipment. Students satisfactorily completing this course are expected to thoroughly understand the current thermal-hydraulics literature on multiphase heat and mass transfer and be able to conduct independent research in this field. (Cross listed as CHME-6840. Students cannot obtain credit for both this course and CHME-6840.) Prerequisite: a working knowledge of fluid mechanics and heat transfer. Fall term annually.  

3 credit hours

MANE-6850 An Introduction to Multiphase Flow and Heat Transfer II
This course is intended to give students a state-of-the-art understanding in multicomponent flow phenomena. Applications in the chemical process, petroleum recovery, and fossil/nuclear power industries are given. Specific areas of coverage include two-phase: fluid mechanics, pressure
drop, modeling and analysis, stability analysis, critical flow and dynamic waves, flow regime analysis, and phase separation and distribution phenomena. (Cross listed as CHME-6850. Students cannot obtain credit for both this course and CHME-6850.) Prerequisite: CHME-6840 or MANE-6840. Spring term annually. 3 credit hours

MANE-6860 Rotary Wing Structural Dynamics I: Vibrations
Dynamics of flexible rotating beams, gyroscopic motion, drive system dynamics. Analysis of fuselage vibrations, with emphasis on rotor-fuselage coupling and design for minimum vibration; vibration test procedures. Prerequisite: MANE-4610. Annually. 3 credit hours

MANE-6870 Rotary Wing Structural Dynamics II: Aeroelastic Stability
Continuation of MANE-6860 with emphasis on aeromechanical and aeroelastic stability of rotors and rotor-pylon systems; stability of linear multi-degree-of-freedom systems; Floquet theory; ground and air resonance, unsteady aerodynamics, stall flutter, test procedures. Prerequisites: MANE-6860, MANE-4900 and MANE-4070 or equivalent. Annually. 3 credit hours

MANE-6890 Mechanical Diagnostics
A comprehensive introduction to mechanical fault detection, isolation, and severity assessment. Topics include mechanical fault signature generating mechanism; advanced mechanical signal processing including time domain processing, frequency domain processing and time-frequency distribution; system identification and model-based diagnostics; pattern classification techniques and diagnostic algorithms for mechanical components including rolling bearings, gears, and cutting tools. Prerequisite: ENGR-4050 or equivalent. Fall term annually. 3 credit hours

MANE-6900 Seminar
Fall and spring terms annually. 0 credit hours

MANE-6940 Individual Projects in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Prerequisite: permission of instructor. Fall and spring terms annually. 3 to 6 credit hours

MANE-6960 Topics in Mechanical Engineering, Aeronautical Engineering, Nuclear Engineering, or Engineering Physics
Fall and spring terms annually. 3 credit hours

MANE-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A,B,C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

MANE-6980 Master's Project
Active participation in a Master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

MANE-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

MANE-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 15 credit hours

MANE Mechanical, Aerospace, and Nuclear Engineering at Hartford (SOE)

MANE-4300 Aeroelasticity
General operator equations of aeroelasticity. Static aeroelastic phenomena. Presentation of transient motion and/or dynamic instability phenomena by developing a current topic in aeroelasticity. Prerequisite: MANE-4310. Offered biannually. 3 credit hours

MANE-4310 Theory of Structures
Normal and shear stresses in beams of nonsymmetric solid and thin-walled cross section subjected to bending and tor-
sion. The principle of virtual displacements and Castigliano’s theorems. Calculation of the stresses in statically determinate and indeterminate trusses, beams, frames, and rings. Structural stability. Offered biannually. 3 credit hours

**MANE-5020 Combustion Engines**

Analysis of the ideal and actual process involved in combustion engines. Optimization of particular cycles for criteria such as maximum performance and efficiency and minimum pollution. Sources of energy for combustion engines such as fuels, oxidants, and propellants. Offered biannually. 3 credit hours

**MANE-5040 Gas Turbine Performance Analysis**

Thermodynamic cycle and force-momentum principles applied to power plant performance analysis; operating performance characteristics of gas turbine components are developed from engineering fundamentals; power plants analyzed as integrated systems in various applications; emphasis on jet propulsion. Offered biannually. 3 credit hours

**MANE-5060 Introduction to Compressible Flow**

One-dimensional isentropic compressible flow. Normal stationary and moving shock waves. Design on inlet and ducted diffusers, steady flow wind tunnels and shock tubes. Flow in ducts with friction and heat transfer. Offered biannually. 3 credit hours

**MANE-5080 Turbomachinery**

Representation of performance of turbomachines; mechanism of energy transfer; factors limiting design and performance including surge, choking, and cavitation; two- and three-dimensional flow phenomena; performance analysis including multistage effects and off-design performance. Offered biannually. 3 credit hours

**MATH Mathematics (SOS)**

**MATH-1010 Calculus I**

Functions, limits, continuity, derivatives, implicit differentiation, related rates, maxima and minima, elementary transcendental functions, introduction to definite integral with applications to area and volumes of revolution. Fall and spring terms annually. 4 credit hours

**MATH-1020 Calculus II**

Techniques and applications of integration, polar coordinates, parametric equations, infinite sequences and series, vector functions and curves in space, functions of several variables, and partial derivatives. Prerequisite: MATH-1010. Fall and spring terms annually. 4 credit hours

**MATH-1500 Calculus for Architecture, Management, and H&SS**

Basic concepts in differential and integral calculus for functions of one variable. Topics will include functions, limits, continuity, derivatives, integration, exponential and logarithmic functions, and techniques of integration. Application areas will include topics in Management, Architecture, and Social Sciences with special emphasis on the role of calculus in introductory probability. Students who have passed MATH-1010 cannot obtain credit for MATH-1500. Prerequisite: major in Management, Architecture or H&SS. Fall term annually. 4 credit hours

**MATH-1520 Mathematical Methods in Management and Economics**

Functions of several variables, introductory linear algebra, and other analytical techniques needed for further study of partial differential equations. Specific numerical approaches (panel method, finite differencing) associated with low speed and viscous flows are discussed in detail. Computer applications of these techniques. Prerequisite: permission of instructor. Offered biannually. 3 credit hours

**MATH-7050 Theory of Potential Flow**

Review of vector operations applied to fluid mechanics, integral theorems, equations of motion, momentum theorem, energy relations. Two-dimensional motion velocity and stream potentials. Complex variables with theorem applications, Cauchy’s theorem mapping, conformal representation. Streaming motions, circle theorem. Offered biannually. 3 credit hours

**MATH-7060 Turbomachinery II**

Compressor surge, rotating stall, cooled turbine performance, supersonic compressors and turbines, blade flutter, asymmetric inlet flow effects, and/or subjects to meet the special interests of students. Prerequisite: MANE-5080. Offered biannually. 3 credit hours

**MATH-7080 Turbomachinery II**

Compressor surge, rotating stall, cooled turbine performance, supersonic compressors and turbines, blade flutter, asymmetric inlet flow effects, and/or subjects to meet the special interests of students. Prerequisite: MANE-5080. Offered biannually. 3 credit hours

**MATH-1010 Calculus I**

Functions, limits, continuity, derivatives, implicit differentiation, related rates, maxima and minima, elementary transcendental functions, introduction to definite integral with applications to area and volumes of revolution. Fall and spring terms annually. 4 credit hours

**MATH-1020 Calculus II**

Techniques and applications of integration, polar coordinates, parametric equations, infinite sequences and series, vector functions and curves in space, functions of several variables, and partial derivatives. Prerequisite: MATH-1010. Fall and spring terms annually. 4 credit hours

**MATH-1500 Calculus for Architecture, Management, and H&SS**

Basic concepts in differential and integral calculus for functions of one variable. Topics will include functions, limits, continuity, derivatives, integration, exponential and logarithmic functions, and techniques of integration. Application areas will include topics in Management, Architecture, and Social Sciences with special emphasis on the role of calculus in introductory probability. Students who have passed MATH-1010 cannot obtain credit for MATH-1500. Prerequisite: major in Management, Architecture or H&SS. Fall term annually. 4 credit hours

**MATH-1520 Mathematical Methods in Management and Economics**

Functions of several variables, introductory linear algebra, and other analytical techniques needed for further study of partial differential equations. Specific numerical approaches (panel method, finite differencing) associated with low speed and viscous flows are discussed in detail. Computer applications of these techniques. Prerequisite: permission of instructor. Offered biannually. 3 credit hours

**MANE-5020 Combustion Engines**

Analysis of the ideal and actual process involved in combustion engines. Optimization of particular cycles for criteria such as maximum performance and efficiency and minimum pollution. Sources of energy for combustion engines such as fuels, oxidants, and propellants. Offered biannually. 3 credit hours

**MANE-5040 Gas Turbine Performance Analysis**

Thermodynamic cycle and force-momentum principles applied to power plant performance analysis; operating performance characteristics of gas turbine components are developed from engineering fundamentals; power plants analyzed as integrated systems in various applications; emphasis on jet propulsion. Offered biannually. 3 credit hours

**MANE-5060 Introduction to Compressible Flow**

One-dimensional isentropic compressible flow. Normal stationary and moving shock waves. Design on inlet and ducted diffusers, steady flow wind tunnels and shock tubes. Flow in ducts with friction and heat transfer. Offered biannually. 3 credit hours

**MANE-5080 Turbomachinery**

Representation of performance of turbomachines; mechanism of energy transfer; factors limiting design and performance including surge, choking, and cavitation; two- and three-dimensional flow phenomena; performance analysis including multistage effects and off-design performance. Offered biannually. 3 credit hours

**MANE-5080 Turbomachinery II**

Compressor surge, rotating stall, cooled turbine performance, supersonic compressors and turbines, blade flutter, asymmetric inlet flow effects, and/or subjects to meet the special interests of students. Prerequisite: MANE-5080. Offered biannually. 3 credit hours
in probability, statistics, and operations research. Topics covered include improper integrals, probability density functions, partial derivatives and optimization techniques for functions of several variables, matrix algebra, linear systems, lines and planes in 3-space, linear inequalities, introductory linear programming, introductory combinatorics, and some probability. Students who have passed MATH-1020 cannot register for this course. Prerequisites: MATH-1010 or MATH-1500 and major in Management or Economics, or permission of instructor. Spring term annually.

MATH-1620 Contemporary Mathematical Ideas in Society
An application-oriented course introducing contemporary mathematical concepts that pertain to areas of Architecture and Humanities and Social Sciences. The course will cover growth and form, symmetry, patterns, tilings, linear programming, information coding, voting systems, game theory, logic, probability and statistics. Prerequisites: major in Architecture, or Humanities and Social Sciences and MATH-1010 or MATH-1500 or permission of instructor. Spring term annually. 4 credit hours

MATH-1900 Art and Science of Mathematics I
A seminar for first-year math majors. The weekly student-faculty discussions will vary but examples of topics are: unsolved math problems, countability and the arithmetic of the infinite, topology and the concept of dimension, geometry and one-sided surfaces, and the theory underlying topics currently covered in calculus. These courses cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement. Prerequisite: first-year math majors. Full term annually. 1 credit hour

MATH-1910 Art and Science of Mathematics II
A seminar for first-year math majors. The weekly student-faculty discussions will vary but examples of topics are: unsolved math problems, countability and the arithmetic of the infinite, topology and the concept of dimension, geometry and one-sided surfaces, and the theory underlying topics currently covered in calculus. These courses cannot be used to help satisfy the eight credit hours of mathematics bachelor’s degree requirement. Prerequisite: first-year math majors. Spring term annually. 1 credit hour

MATH-2010 Multivariable Calculus and Matrix Algebra
Directional derivatives, maxima and minima, double integrals, line integrals, div and curl, and Green’s Theorem; matrix algebra and systems of linear equations, vectors and linear transformations in R^n, eigenvectors and eigenvalues, applications in engineering and science. Prerequisite: MATH-1020. Fall and spring terms annually. 4 credit hours

MATH-2400 Introduction to Differential Equations
First-order differential equations, second-order linear equations, eigenvalues and eigenvectors of matrices, systems of first-order equations, stability and qualitative properties of nonlinear autonomous systems in the plane, Fourier series, separation of variables for partial differential equations. Prerequisites: MATH-1020 and some knowledge of matrices. Fall and spring terms annually.

MATH-2700 Fundamentals of Mathematics
This course is designed to assist students who will be taking 4000-level advanced mathematics courses. The main emphasis is on the development of sound mathematical reasoning and construction of solid mathematical proofs. Mathematical ideas and concepts from the foundations of the number system, set theory, logic, algebra, and elementary topology are selected as illustrations. Students are challenged to develop their own conceptual understanding of the mathematical proof, and to defend their mathematical positions. Prerequisite: math major or permission of instructor, and MATH-1020. Spring term annually. 4 credit hours

MATH-2800 Introduction to Discrete Structures
Introduction to the mathematical foundation of computer science. Topics include logic and set theory; methods of proof; mathematical induction and well-ordering; principles of counting; relations and graphs; recurrences; discrete probability. Prerequisite: MATH-1010 or MATH-1500 or equivalent. Spring term annually. 4 credit hours

MATH-2940 Readings in Mathematics
1 to 4 credit hours

MATH-2960 Topics in Mathematics
1 to 4 credit hours

MATH-4010 Abstract Algebra
Groups, rings, polynomial rings, fields, integral domains, with emphasis on group theory; homomorphisms and isomorphisms; normal subgroups, cosets, ideals, modules; quotient groups and quotient rings; other topics including algebraic aspects of set theory, of relations and functions, and of number theory. Prerequisite: a readiness to reason abstractly; MATH-4100 is desirable but not required. Spring term annually. 4 credit hours

MATH-4020 Introduction to Number Theory
Topics include the history of number representation systems, divisibility, greatest common divisor and prime factorization, linear Diophantine equations, congruences, and condition congruences. Additional topics may be chosen from cryptology, the perpetual calendar, hashing functions, computer operations and complexity, continued fractions, multiplicative functions, primitive roots, pseudo-random numbers, nonlinear Diophantine equations, Fermat’s last theorem, algebraic numbers, and approximation of numbers by rationals. Prerequisite: MATH-1020. Spring term odd-numbered years. 4 credit hours
MATH-4040 Introduction to Topology
Topics include general topological spaces, connectedness, compactness, continuity, and product spaces. Additional topics may be chosen from Mobius strips, Klein bottles, identification spaces, homotopy, the fundamental group of a surface, sequences in topological spaces, pseudo-metric spaces, completeness, Baire category, space-filling curves, weak topologies, quotient spaces, strong topologies, hyperspaces, the Hausdorff metric, and topological dimension. Corequisite: MATH-4200. Fall term even-numbered years.
4 credit hours

MATH-4100 Linear Algebra
The theory underlying vector spaces, algebra of subspaces, bases; linear transformations, dual spaces; eigenvectors, eigenvalues, minimal polynomials, canonical forms of linear transformations; inner products, adjoints, orthogonal projections and complements. Prerequisite: MATH-2010. Fall term annually.
4 credit hours

MATH-4120 Fundamentals of Geometry
Topics may be chosen from differential geometry of curves and surfaces, involutes and evolutes, order of contact, developable surfaces, Euler's and Meusnier's Theorem, mean and Gaussian curvatures, geodesics and parallel transport, The Theorem Egregium of Gauss, Gauss-Bonnet Theorem, computer-aided geometric design, computational geometry, tessellations, tiling and patterns, projective and non-Euclidean geometries, postulates and axiomatic systems, advanced Euclidean geometry, and the history of geometry. Prerequisites: MATH-2010 and MATH-4600 or permission of the instructor. Fall term even-numbered years.
4 credit hours

MATH-4150 Graph Theory
Fundamental concepts and methods of graph theory and its applications in various areas of computing and the social and natural sciences. Topics include graphs as models, representation of graphs, trees, distances, matchings, connectivity, flows in networks, graph colorings, Hamiltonian cycles, traveling salesman problem, planarity. All concepts, methods, and applications are presented through a sequence of exercises and problems, many of which are done with the help of novel software systems for combinatorial computing. (Cross listed as CSCI-4260. Students cannot obtain credit for both this course and CSCI-4260.) Prerequisite: CSCI-2300. Spring term even-numbered years.
4 credit hours

MATH-4200, MATH-4210 Mathematical Analysis I, II
Fundamental concepts of mathematical analysis. A two-term sequence covering such topics as the real number system, limits, sequences, series, convergence, uniform convergence, functions of one variable, continuity, differentiability, Riemann integration, functions of several variables, line, surface, and volume integrals. Qualified as a writing-intensive course. Prerequisites: differential and integral calculus. Fall-spring sequence annually.
4 credit hours each

MATH-4300 Introduction to Complex Variables: Theory and Applications
An introduction to the theory and applications of complex variables. Topics include analytic functions, Riemann surfaces, complex integration, Taylor and Laurent series, residues, conformal mapping, harmonic functions, and Laplace transforms. Applications will be to problems in science and engineering such as fluid and heat flow, dynamical systems, and electrostatics. Prerequisite: MATH-2010 or equivalent. Spring term annually.
4 credit hours

MATH-4400 Ordinary Differential Equations and Dynamical Systems
An intermediate course emphasizing a modern geometric approach and applications in science and engineering. Topic include first-order equations, linear systems, phase plane, linearization and stability, calculus of variations, Lagrangian and Hamiltonian mechanics, oscillations, basic bifurcation theory, chaotic dynamics, and existence and uniqueness. Prerequisite: MATH-2400 or permission of instructor. Fall term annually.
4 credit hours

MATH-4500 Methods of Partial Differential Equations of Mathematical Physics
An intermediate course serving to introduce both the qualitative properties of solutions of partial differential equations and methods of solution, including separation of variables. Topics include first-order equations, derivation of the classical equations of mathematical physics (wave, potential, and heat equations), method of characteristics, construction and behavior of solutions, maximum principles, energy integrals. Prerequisite: MATH-4600 or permission of instructor. Spring term annually.
4 credit hours

MATH-4600 Advanced Calculus
Topics include differentials and derivatives of functions of several variables, Jacobians, Lagrange multipliers, line, surface and volume integrals, independence of path, curvilinear coordinates, vector calculus, calculus of variations, theorems of Green, Gauss, and Stokes. Prerequisite: MATH-2010. Fall and spring terms annually.
4 credit hours

MATH-4700 Foundations of Applied Mathematics
Mathematical formulation of models for various processes. Derivation of relevant differential equations from conservation laws and constitutive relations. Use of dimensional analysis, scaling, and elementary perturbation methods. Description of basic wave motion. Examples from areas including biology, elasticity, fluid dynamics, particle mechanics, chemistry, geophysics, and finance. Prerequisite: MATH-2400 or equivalent. Fall term annually.
4 credit hours
MATH-4720 Mathematics in Medicine and Biology
An introduction to mathematics used in biology, biophysics, biomedical engineering, and medicine. The mathematical topics covered are selected from calculus, linear algebra, differential equations, numerical methods, and Fourier analysis. The biological applications covered are selected from human physiology (heart, lung, brain), population models (microorganisms, cells, animals), and the diagnosis and treatment of disease (heart, cancer). Prerequisite: MATH-1020. Fall term odd-numbered years.

4 credit hours

MATH-4740 Mathematics of Finance
This course is designed to introduce students to mathematical and computational finance. Topics include a mathematical approach to risk analysis, portfolio selection theory, futures, options and other derivative investment instruments. Finite difference and finite element methods for computing American option prices are discussed. A working knowledge of MAPLE or MATLAB is required to compute optimal portfolios. Prerequisite: MATH-1020. Spring term odd-numbered years.

4 credit hours

MATH-4800 Numerical Computing
A survey of numerical methods for scientific and engineering problems. Topics include numerical solution of linear and nonlinear algebraic equations, interpolation and least squares approximations, numerical integration and differentiation, eigenvalue problems, and an introduction to the numerical solution of ordinary differential equations. Emphasis placed on efficient computational procedures including the use of library and student written procedures using high-level software such as MATLAB. (Cross listed as CSCI-4800. Students cannot obtain credit for both this course and CSCI-4800.) Prerequisite: CSCI-1100 and MATH-2010 or ENGR-1100. Corequisite: MATH-2400. Fall and spring terms annually.

4 credit hours

MATH-4820 Introduction to Numerical Methods for Differential Equations
Derivation, analysis, and use of computational procedures for solving differential equations. Topics covered include ordinary differential equations (both initial value and boundary value problems) and partial differential equations. Runge-Kutta and multistep methods for initial value problems. Finite difference methods for partial differential equations including techniques for heat conduction, wave propagation, and potential problems. Basic convergence and stability theory. (Cross listed as CSCI-4820. Students cannot obtain credit for both this course and CSCI-4820.) Prerequisite: MATH-4800 or CSCI-4800 Spring term annually.

4 credit hours

MATH-4940 Readings in Mathematics
1 to 4 credit hours

MATH-4960 Topics in Mathematics
1 to 4 credit hours

MATH-4980 Undergraduate Project in Mathematics
1 to 4 credit hours

MATH-6190 Topics from Pure Mathematics
The course is intended to provide a mathematical perspective on one or more topics chosen from algebra, geometry, and/or topology. Topics may include combinatorial matrix theory, classification of surfaces, Lie groups, Galois theory, geometric analysis, computational geometry, homology, and/or fixed point theorems. Prerequisites: vary with topic. Spring term even-numbered years.

4 credit hours

MATH-6200 Real Analysis
A careful study of measure theory, including abstract and Lebesgue measures and integration, absolute continuity and differentiation, L^p spaces, Fourier transforms and Fourier series, Hilbert spaces and normed linear spaces. Prerequisite: MATH-4210 or equivalent or permission of instructor. Spring term even-numbered years.

4 credit hours

MATH-6220 Introduction to Functional Analysis
A basic course in the concepts of linear functional analysis, including such topics as linear functionals, bounded linear operators, unbounded linear operators, graphs, adjoints, spectral theory of linear operators, and applications to differential equations and mathematical physics. Prerequisites: MATH-4210, MATH-4300, or permission of instructor; MATH-6200 or equivalent also desirable. Fall term annually.

4 credit hours

MATH-6240 Functional Analysis and Analysis for Nonlinear Operators
A continuation of material presented in MATH-6220. Covers such topics as inverse and implicit function theorems, fixed point theorems, Riesz bases, distributions and Sobolev spaces, variational methods, degree theory, and applications to differential equations. Prerequisite: MATH-6220 or equivalent or permission of instructor. Spring term odd-numbered years.

4 credit hours

MATH-6300 Complex Analysis
A basic graduate course covering Cauchy’s Theorem, residues, infinite series and products, partial fractions, conformal mapping and the Riemann mapping theorem, analytic continuation, zeros and growth of analytic functions, approximation by rational functions, Phragmen-Lindelof Theorems, inverse-scattering theory, elliptic functions, and Riemann Surfaces. Prerequisites: MATH-4210 and MATH-4300 or equivalent or permission of instructor. Term(s) Offered: Full term odd-numbered years.

4 credit hours
MATH-6400 Ordinary Differential Equations
A basic graduate course introducing the fundamental concepts of modern evolution equations theory in the setting of ordinary differential equations. Topics include existence and uniqueness, integral equations, stability of equilibria, stable manifolds, Floquet theory, Poincare-Bendixon theory, bifurcation theory, center manifolds, normal forms, averaging theory, Hamiltonian mechanics and calculus of variations, chaotic dynamics, KAM theory, and soliton theory. Prerequisite: MATH-4400 or permission of instructor. Spring term even-numbered years. 4 credit hours

MATH-6490 Topics in Ordinary Differential Equations
Mathematical foundations and/or applications of ordinary differential equations. Possible topics include: stability and chaos in dynamics, mathematical methods of classical mechanics, stochastic differential equations, and soliton equations. Listing of topics offered to date. Prerequisites: Vary with topic. Term(s) Offered: Spring term odd-numbered years. 4 credit hours

MATH-6500 Partial Differential Equations
A course dealing with the basic theory of partial differential equations. It includes such topics as properties of solutions of hyperbolic, parabolic, and elliptic equations in two or more independent variables; linear and nonlinear first order equations; existence and uniqueness theory for general higher order equations; potential theory and integral equations. Prerequisite: MATH-4210 or equivalent or permission of instructor. Fall term annually. 4 credit hours

MATH-6590 Topics in Partial Differential Equations
Mathematical foundation and/or applications of partial differential equations. Possible topics include soliton theory and applications, wavelets and PDEs, scattering theory, hyperbolic conservation laws. Prerequisites: vary with topic. Spring term annually. 4 credit hours

MATH-6600 Methods of Applied Mathematics
Linear vector spaces; eigenvalues and eigenvectors in discrete systems; eigenvalues and eigenvectors in continuous systems including Sturm-Liouville theory, orthogonal expansions and Fourier series, Green's functions; elementary theory of nonlinear ODEs including phase plane, stability and bifurcation; calculus of variations. Applications will be drawn from equilibrium and dynamic phenomena in science and engineering. Prerequisites: MATH-2400 and MATH-4600. Fall term annually. 4 credit hours

MATH-6620 Perturbation Methods
This course is devoted to advanced methods rather than theory. Content includes such topics as matched asymptotic expansions, multiple scales, WKB, and homogenization. Applications are made to ODEs, PDEs, difference equations, and integral equations. The methods are illustrated using currently interesting scientific and engineering problems that involve such phenomena as boundary or shock layers, nonlinear wave propagation, bifurcation and stability, and resonance. Prerequisites: MATH-2400 and MATH-4600 or equivalent. Spring term even-numbered years. 4 credit hours

MATH-6640 Complex Variables and Integral Transforms with Applications
Review of basic complex variables theory; power series, analytic functions, singularities, and integration in the complex plane. Integral transforms (Laplace, Fourier, etc.) in the complex plane, with application to solution of PDEs and integral equations. Asymptotic expansions of integrals (Laplace method, methods of steepest descent and stationary phase), with emphasis on extraction of useful information from inversion integrals of transforms. Problems to be drawn from linear models in science and engineering. Prerequisites: MATH-4600 and familiarity with elementary ordinary and partial differential equations. Spring term odd-numbered years. 4 credit hours

MATH-6790 Topics in Applied Mathematics
Advanced methods and/or applications of mathematics. Possible topics include: nonlinear continuum mechanics, nonlinear waves, inverse problems, nonlinear optics, combustion, acoustic wave propagation, similarity methods for differential equations, quantum field theory and statistical mechanics, stability of fluid flows, biomathematics, and finance. Prerequisites: vary with topic. Spring term annually. 4 credit hours

MATH-6800 Computational Linear Algebra
Gaussian elimination, special linear systems (such as positive definite, banded, or sparse), introduction to parallel computing, iterative methods for linear systems (such as conjugate gradient and preconditioning), QR factorization and least squares problems, and eigenvalue problems. (Cross listed as CSCI-6800. Students cannot obtain credit for both this course and CSCI-6800.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term annually. 4 credit hours

MATH-6820 Numerical Solution of Ordinary Differential Equations
Numerical methods and analysis for ODEs with applications from mechanics, optics, and chaotic dynamics. Numerical methods for dynamical systems include Runge-Kutta, multistep and extrapolation techniques, methods for conservative and Hamiltonian systems, methods for stiff differential equations and for differential-algebraic systems. Methods for boundary value problems include shooting and orthogonalization, finite difference and collocation techniques, and special methods for problems with boundary or shock layers. (Cross listed as CSCI-6820. Students cannot obtain credit for both this course and CSCI-6820.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term odd-numbered years. 4 credit hours
MATH-6840 Numerical Solution of Partial Differential Equations
Numerical methods and analysis for linear and nonlinear PDEs with applications from heat conduction, wave propagation, solid and fluid mechanics, and other areas. Basic concepts of stability and convergence (Lax equivalence theorem, CFL condition, energy methods). Methods for parabolic problems (finite differences, method of lines, ADI, operator splitting), methods for hyperbolic problems (vector systems and characteristics, dissipation and dispersion, shock capturing and tracking schemes), methods for elliptic problems (finite difference and finite volume methods). (Cross listed as CSCI-6840. Students cannot obtain credit for both this course and CSCI-6840.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Fall term odd-numbered years. 4 credit hours

MATH-6860 Finite Element Analysis
Galerkin's method and extremal principles, finite element approximations (Lagrange, hierarchical and 3-D approximations, interpolation errors), mesh generation and assembly, adaptivity (h-, p-, hp-refinement). Error analysis and convergence rates. Perturbations resulting from boundary approximation, numerical integration, etc. Time dependent problems including parabolic and hyperbolic PDEs. Applications will be selected from several areas including heat conduction, wave propagation, potential theory, and solid and fluid mechanics. (Cross listed as CSCI-6860. Students cannot obtain credit for both this course and CSCI-6860.) Prerequisite: MATH-4800 or CSCI-4800 or permission of instructor. Spring term even-numbered years. 4 credit hours

MATH-6890 Topics in Computational Mathematics
Advanced methods and/or applications in scientific computing. Possible topics include computational fluid dynamics, parallel computing, computational acoustics, and computer applications in medicine and biology. Prerequisites: vary with topic. Fall term even-numbered years. 4 credit hours

MATH-6940 Readings in Mathematics
1 to 4 credit hours

MATH-6950 Teaching Seminar for Teaching Assistants
A seminar required for first-year TAs in mathematics. Prerequisite: first-year math TA. Fall term annually. 1 credit hour

MATH-6951 Introduction to Research in Mathematics
This seminar introduces first-year graduate students in mathematics to the faculty and their research. Each week a different faculty member from math will give introductory presentations of their current research areas in a setting that is conducive for significant student-faculty discussions of the material. Prerequisites: graduate student in mathematics Spring term annually. 4 credit hours

MATH-6960 Topics in Mathematics
1 to 4 credit hours

MATH-6970 Master's Practicum in Mathematics
Active participation in a professional experience in mathematics, under the supervision of a faculty adviser. A Master's Practicum may serve as the capstone professional experience for the M.S. degree. A Master's Practicum may result in documentation as required by the adviser, but is not submitted to the Graduate School and is not archived in the library. Grades of A, B, C, or F are assigned if credit is awarded for the Master's Practicum. Students may not receive credit for both MATH-6970 and MATH-6980. 0 to 6 credit hours

MATH-6980 Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 6 credit hours

MATH-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

MATP Mathematical Programming, Probability, and Mathematical Statistics (SOS)

MATP-4600 Probability Theory and Applications
Axioms of probability, joint and conditional probability, random variables, probability density and distribution functions, expectation, functions of random variables, and limit theorems. Applications of probability to models in operations research, including queuing theory and Markov chains. (Cross listed as DSES-4750. Students cannot obtain credit for both this course and DSES-4750.) Prerequisite: MATH-1020 or equivalent or permission of instructor. Fall term annually. 4 credit hours
MATP-4620 Mathematical Statistics
A course in the theory of statistics that will provide students with a basic foundation for more specialized statistical methodology courses. Topics include sampling and sampling distributions; point estimation including method of moments, maximum likelihood estimation, uniform minimum variance estimation, and properties of the associated estimators; hypothesis testing including uniformly most powerful, likelihood ratio, chi-square goodness-of-fit tests, and tests for independence. The course concludes with an introduction to linear statistical models. (Cross-listed as DSES-4760. Students cannot obtain credit for both this course and DSES-4760.) Prerequisite: DSES-4750 or MATP-4600 or equivalent calculus-based course. Spring term annually.

MATP-4700 Mathematical Models of Operations Research
Introduction to deterministic models of operations research including linear programming formulations, the simplex algorithm, degeneracy, geometry of convex polyhedra, duality theory, and sensitivity analysis. Special linear programming models for assignment, transportation, and network problems. Integer programming formulations along with branch and bound solution. Dynamic programming. (Cross listed as DSES-4770. Students cannot obtain credit for both this course and DSES-4770.) Prerequisites: MATH-1020, and MATH-2010 or ENGR-1100, or equivalent, or permission of instructor. Fall term annually.

MATP-4820 Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcomed in this course. A course project will allow students to explore optimization methods and practical problems directly related to their interests. A computer implementation and a research presentation will be required. Students cannot obtain credit for both this course and DSES-4760. Spring term annually.

MATP-4940 Readings in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-4960 Topics in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-4980 Undergraduate Project in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-6600 Nonlinear Programming
Convex sets and functions, optimality conditions in nonlinear programming, Lagrangian duality, quadratic programming; algorithms for nonlinear programming including Newton’s method, quasi-Newton methods, conjugate gradient methods, together with proofs of convergence. (Cross listed as DSES-6760. Students cannot obtain credit for both this course and DSES-6760.) Prerequisite: MATP-4200 or equivalent or permission of instructor. Spring term annually.

MATP-6610 Computational Optimization
An introduction to nonlinear programming. Models, methods, algorithms, and computer techniques for nonlinear optimization are studied. Students investigate contemporary optimization methods both by implementing these methods and through experimentation with commercial software. Nonmajors wishing to gain practical optimization skills are welcomed in this course. A course project will allow students to explore optimization methods and practical problems directly related to their interests. A computer implementation and a research presentation will be required. Students cannot obtain credit for both this course and DSES-4780 or MATP-6610. Spring term annually.

MATP-6620 Combinatorial Optimization and Integer Programming
Exact and heuristic methods for solving discrete problems, including the traveling salesman problem, the knapsack problem, packing and covering problems. Algorithm complexity and NP-completeness, cutting plane methods and polyhedral theory, branch and bound, simulated annealing, tabu search, Lagrangian duality. (Cross listed as DSES-6760. Students cannot obtain credit for both this course and DSES-6760.) Prerequisite: MATP-4700 or DSES-4770. Spring term odd-numbered years.

MATP-6640 Linear Programming
A unified development of linear systems and linear programming, polyhedral theory, the simplex method, interior point methods, decomposition methods for large-scale linear programming problems, the ellipsoid method, column generation algorithms for stochastic programming, and other problems. (Cross listed as DSES-6770. Students cannot obtain credit for both this course and DSES-6770.) Prerequisites: MATP-4700 or DSES-4770. Spring term even-numbered years.

MATP-6940 Readings in Mathematical Programming, Probability, and Mathematical Statistics
1 to 4 credit hours

MATP-6960 Topics in Optimization
Advanced methods and/or applications in optimization.
Possible topics include stochastic programming, learning theory, cone programming, optimization of medical treatment, and network flows. Prerequisites: vary with topics and/or instructor. Fall term annually.  

4 credit hours

MATEP-6980 Master’s Project
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S.

1 to 6 credit hours of the three primary financial statements: the income statement, the balance sheet, and the cash flow statement. The introduction to managerial accounting includes profit-volume relationships, cost systems, evaluation and control, and budgeting. Fall and spring terms annually.

4 credit hours

MGMT-2320 Managerial Finance
Introduction to corporate financial analysis and decision making. Focus is on various finance functions in modern firms. Topics include valuation principles, risk and return analysis, working capital management, capital budgeting, short- and long-term financing decision making, analysis of equity and debt financing, cost of capital and optimal capital structure, dividend policy. Prerequisite: MGMT-2300 or permission of instructor. Fall and spring terms annually.

4 credit hours

MGMT-2510 Microcomputers and Applications
An introduction to the fundamentals of microcomputer technology and its application in management and information systems. Topics include hardware, software, communications and elements of the system design life cycle, database concepts, and data processing. Students build systems using spreadsheet and database packages. Restricted to management majors. Fall and spring terms annually.

4 credit hours, 5 contact hours

MGMT-2940 Studies in Management
Student plans a course of selected topics in management theory or practice not listed in this catalog. The instructor who will supervise and grade the student must approve the plan. Lectures, discussions, conferences, or seminars may be used in conjunction with the independent study. A written report is required; examinations may be required by the instructor. Prerequisite: permission of instructor. Fall and spring terms annually.

1 to 4 credit hours per course, not to exceed 12 for this course number

MGMT-2960 Topics in Management
4 credit hours

MGMT-4020 Junior Achievement
Junior Achievement Inc. is a nonprofit organization financed by over 100,000 businesses, foundations, and individuals. Junior Achievement’s stated purpose is to educate and inspire young people to value free enterprise, to understand business and economics, and to become workforce ready. It is the purpose of the class to carry out Junior Achievement’s mission in the 6th, 7th, and 8th grade classes that students will teach at Doyle Middle School in Troy, NY. All materials are provided, and students will have a unique opportunity to develop presentation and leadership skills while contributing to the youth of our community. Fall and spring terms annually.

4 credit hours

MGMT-4100 Quantitative Methods for Business
This course introduces the student to the business management of production and operations systems. The con-
cepts are related to inventory control, forecasting, scheduling, man-powers, and facilities planning. Computer usage includes Excel and specialized packages. Fall and spring terms.

MGMT-4110 Operations Management
This course introduces the student to the operations function in services and manufacturing-oriented firms. Students develop an appreciation of the concepts, principles, and techniques used for decision making in the operations function. The course takes a managerial perspective. Prerequisites include: MGMT-2100. Fall and spring terms annually. 4 credit hours

MGMT-4130 Enterprise IT Integration
This course provides a capstone and professional experience through an in-depth study of major issues in enterprise information architecture. The course emphasizes both management and technical issues. Topics include information architecture evaluation, strategic information technology alignment, information technology valuation techniques, application interfaces, system and data integration, data warehousing, and decision support systems. Course concepts are developed through case studies and projects. Prerequisites: CSCI-2300 or equivalent and MGMT-1100 or equivalent, or permission of the instructor. Spring term annually. 4 credit hours

MGMT-4140 Computer Information Systems
This course provides the undergraduate management student with an introduction to the concept and components of computer-based "management information systems" (MIS) and their integration into organizational processes to gain competitive advantage. In the course, we will examine approaches for developing and using information systems in support of business processes. Topics include: the impact of computer-based information systems on organizations; the basic technology components of modern information systems; the process by which information systems are created and changed; and selected management and technology issues. Fall and spring terms. 4 credit hours

MGMT-4150 IT Project Management
This capstone concentration course provides the student with conceptual and applied material focusing on the effective implementation of information. A central theme underlying this course is that information system implementation is best thought of as a bridge between systems design and utilization and that it must be understood in the context of the development process as a whole. The course examines a wide array of interrelated issues not generally covered in a systems analysis and design course including: project development life cycle; project management and systems engineering; process reengineering and maturity; organizational learning and evaluation. Fall and spring terms annually. 4 credit hours

MGMT-4160 Telecommunications for Business
Rapid advancements in telecommunications technology and the convergence of computing and telecommunications have created unique opportunities for organizations to derive competitive advantage. Telecommunications technology has become an essential feature of the business environment and is embodied in both operations and products/services of organizations. This course aims to analyze how telecommunications can be employed to enhance the benefits and reduce the costs through the value web. A wide variety of telecommunications technologies ranging from narrowband to broadband and from wired to wireless will be examined in detail. The primary emphasis will be on issues related to their application in different business contexts. Fall and spring terms annually. 4 credit hours

MGMT-4200 Financial Accounting and Reporting I
An examination of the general theory and concepts of accounting and "generally accepted accounting principles" as applied to assets. Included is a study of the relationships between asset valuation and income determination, with an emphasis on alternative capital maintenance concepts, asset valuation, and revenue recognition bases, and price level and current value accounting. Prerequisite: MGMT-2300 or equivalent. Offered on availability of instructor. 4 credit hours

MGMT-4210 Auditing for Managerial Control
The theory and practice of financial auditing and the preparation of audit programs along with operations, internal and management auditing for compliance, program results, economy, and efficiency. Prerequisite: MGMT-4200. Offered on availability of instructor. 4 credit hours

MGMT-4220 Accounting Information Systems
This course provides the background for understanding how the accounting system works and also how the accounting system fits into the overall information system of the firm. Prerequisite: MGMT-2300. Offered on availability of instructor. 4 credit hours

MGMT-4230 Manufacturing Accounting and Control Systems
This course provides the students with an understanding of basic cost accounting and of current topics in manufacturing accounting. In particular, the course covers activity-based costing and management systems, standard costing, and transfer pricing. Although the course is primarily oriented toward manufacturing environments, the principles covered are directly applicable to service industries. Prerequisites: MGMT-2300 and MGMT-2100. Offered on availability of instructor. 4 credit hours

MGMT-4240 Systems Analysis and Design
This course presents conceptual material on the analysis and design of business information systems. The focus is on understanding business information processing requirements and developing information systems solutions to meet these requirements. Key stages of the systems development life cycle including planning, analysis, and design are the focus of this course. Models and procedures for
understanding and modeling an organization's existing and planned information systems are presented. Computer-aided software engineering tools are used to provide hands-on experience in designing information systems. Fall and spring terms.

MGMT-4310 Financial Trading and Investing
This course introduces interactive trading in financial instruments. Students learn the principles of asset price discovery through real-time trading in a variety of markets, including equities, bonds, options, derivatives. Topics addressed include asset valuation, portfolio management, and risk management in the context of real-time trading of financial instruments. The course uses the facilities of the Lally School’s Virtual Trading Room. Prerequisites: MGMT-2320 and two upper-level finance courses or permission of the instructor. Spring term annually.

MGMT-4320 Investments I
Introduction to financial markets, financial instruments, and basic investment principles. The course provides students with an understanding of how to value securities, how to assess risk and return tradeoffs, how to make investment decisions, and how to measure investment performance. Topics include market microstructure and impact of technology on securities markets, principles of investment banking, valuation of stocks and bonds and hybrid instruments, portfolio theory, asset pricing models, bond portfolio management, and derivative securities. Prerequisite: MGMT-2320. Fall and spring terms annually.

MGMT-4330 Investments II
Advanced course in investment decision making. Analysis of investment strategies in national and international equity markets including emerging markets. Other topics include arbitrage pricing principles, portfolio insurance, study of the term structure of interest rates and interest rate forecasts, duration analysis, and bond portfolio management, including immunization and active strategies. Principles of option and futures pricing and strategies in options and futures markets. Prerequisites: MGMT-2320 and MGMT-4320. Fall and spring terms annually.

MGMT-4340 Advanced Corporate Finance
Advanced topics in financial theory and corporate policy as they are applied to the modern corporation. Emphasis in blending theory with application. Case studies are used to illustrate relevance of theoretical concepts. Topics include corporate financial decision making under uncertainty, financial forecasting, application of option pricing principles to capital budgeting decision making, mergers and acquisitions, leveraged buyouts and takeovers, leasing, financial engineering. Prerequisites: MGMT-2320 and MGMT-4320 or permission of instructor. Fall and spring terms annually.

MGMT-4370 Risk Management
Analysis and management of some nonspeculative risks in business, and management devices available for dealing with them. Insurance, the most important of these, is dealt with extensively. Intelligent employment of insurance makes possible the transfer of significant risks, at minimum and known cost. Self-insurance considered. Case studies are employed to demonstrate the principles and objectives of static risk management. Prerequisite MGMT-2320. Spring term annually.

MGMT-4380 Derivatives Markets
This course introduces the institutional structure of the financial markets for derivatives. It also covers hedging and basis risk, interest rate, and stock-index derivatives with financial management applications. Other topics covered include an introduction to options, rational option pricing restrictions, binomial option pricing model, and put and call option strategies. Prerequisites: MGMT-2320 and MGMT-4320 or permission of instructor. Spring term biannually.

MGMT-4430 Marketing Principles
Consumer demand analysis: development of static demand relations, fluctuations in demand, attitudes and motivation; the purchase decision, innovation, fashion, and social organization and communications as factors in demand. Industrial demand derived from production functions; input-output analysis derived from capital flows and investment decisions. Application to market research and sales forecasting; elementary study of market structure; adaptive behavior of the firm; pricing, product development, and promotion decisions. Case analysis is employed. Fall and spring terms annually.

MGMT-4460 Consumer Behavior and Product Design
This course introduces the motivations and related factors that shape consumers’ purchasing decisions. Also considered is the consumer perceptual process and how it affects purchasing behavior and consumer reaction to product designs. The relationship between perception and product design is extended to topics such as design for understanding, universal product design, aesthetics, and industrial design. Prerequisites: MGMT-4430 or permission of the instructor. Spring term annually.

MGMT-4470 Marketing Research
A course on identifying and solving marketing problems through the systematic gathering and analysis of market information. Course focuses on careful definition of marketing problems, specification of information needs, sampling theory, research design, statistical methods, and marketing management implications. A major project
involving marketing research for an off-campus “client” is a key part of the final grade. Prerequisites: DSES-2010 or equivalent and MGMT-4430. Fall term annually.

4 credit hours

MGMT-4490 Advertising Strategy and Promotions
Development of creative strategies to accomplish marketing objectives in a competitive environment forms the core rationale for this course. The development of media plans and schedules to deliver advertising promotions element in the marketing mix. Prerequisite: MGMT-4430 or permission of instructor. Spring term annually. 4 credit hours

MGMT-4510 Invention, Innovation, and Entrepreneurship
Employs lectures, exercises, projects, and guest speakers to develop students’ understanding and capability in the creative thinking process as applied to Invention, Innovation, and Entrepreneurship. Fall and spring terms annually. 4 credit hours

MGMT-4520 Introduction to Technological Entrepreneurship
An introductory course for initiating a new business venture and developing it into a self-sustaining and profitable enterprise. Provides understanding of the process whereby a person decides to become an entrepreneur, screens opportunities, selects an appropriate product/market target, and obtains the necessary resources. Also, provides the theoretical and practical knowledge for the preparation of formal business plans for the development of new products, processes, services and for the financing of new enterprises. Fall and spring terms annually. 4 credit hours

MGMT-4530 Starting Up a New Venture
An understanding of the critical issues related to starting up a new business is gained through team-based experiential learning. Small teams of students develop a comprehensive business plan that can be used to raise money for a new or relatively new venture. The business plans are eligible for submission to the Rensselaer Business Plan Competition. The experiential learning process is enhanced through team meetings with faculty and/or course advisers and through oral presentations to the entire class. Fall and spring terms annually. 4 credit hours

MGMT-4550 Business Models for Digital Enterprises
This course is designed as a survey introduction of the range of topics in an e-business. It will consider both entrepreneurial and ongoing organizations. It considers examples of both entrepreneurial approaches and innovation within established companies in areas such as business-to-business (B2B) trends and business-to-consumer (B2C) or e-commerce. Topics include: supply chain management, customer resource planning, enterprise and venture capital, organizational design and virtual firms, security and privacy, finance and valuation, and implementation of e-business technologies and strategies in existing firms. The course will evolve due to the varied interests of participants and changes in the e-business marketplace. Prerequisites: MGMT-1100, MGMT-2300, MGMT-2320, MGMT-4140 or equivalent information technology course, or permission of the instructor. Fall term annually. 4 credit hours

MGMT-4850 Managing the High-Performance Organization I
This course provides an overview of basic processes that influence the work performance of individuals and groups. Topics covered will include (1) processes occurring largely within individuals (for example, perception, work-related attitudes, motivation, stress) and (2) processes involving interactions between employees (for example: influence, cooperation, conflict, group decision making, leadership). Numerous exercises and demonstrations will be conducted during class to provide students with insights into these processes. Fall and spring terms annually. 4 credit hours

MGMT-4860 Managing the High-Performance Organization II
Principles and tools of total quality management and reengineering in an organizational context. The examination of organizational and behavioral characteristics that facilitate evolutionary and revolutionary change. Fall and spring terms annually. 4 credit hours

MGMT-4870 Strategy and Policy
A capstone course that integrates the functional fields of management. The first part of the course focuses on the tools and discipline commonly used in strategy formulation. The second part focuses on the implementation of strategy in a variety of contexts. Prerequisites: MGMT-4860; recommended senior standing. Fall and spring terms annually. 4 credit hours

MGMT-4900 Practicum in Management
A problem-solving experience in a business enterprise or public organization in which the student works individually or in a team project. 1 to 8 credit hours

MGMT-4940 Studies in Management
1 to 8 credit hours

MGMT-4960 Topics in Management
4 credit hours

MGMT-6100 Statistics and Operations Management I
Management, finance, technology, operations, general business operations, and statistical topics are integrated from the point of view of extracting, interpreting, and communicating information. One- and higher-dimensional graphical methods and tabular arrays are used to show that statistical models are natural consequences of business and technology management. Design of investigations and time-related phenomena are covered in depth throughout the course. Statistical simulation of service and production facilities are principal tools for developing information for
MGMT-6110 Statistics and Operations Management II
This course continues the study of collection, analysis, and use of information in a technologically advanced setting. This course shifts focus from statistical methods to other problem-solving approaches, including linear programming, network models, queuing systems, and simulation. The emphasis is on integration of analysis techniques to address the management issues at hand, with application drawn from production, finance, project management, and system design. Case studies are used to supplement traditional homework assignments. Prerequisite: MGMT-6100. (Limited to part-time MBA students). Summer term annually.

MGMT-6120 E-Business Fundamentals
This course is designed as a survey overview of e-business from newly created to large established businesses. It will use business analysis techniques to develop a critical analysis of e-business models. Topics include: strategies of e-business, business models, ERP, ASP, CRM, B2B, B2C, ISP, ethics and security concerns. Fall and summer terms.

MGMT-6130 Research Seminar in Management Information Systems
This doctoral seminar examines the major streams of theory and research in information management and information systems. The course will explore the major issues, theories, and research methods in information systems, research through classic readings, information management, and reference disciplines. Key areas in information systems research will be covered, such as strategic and economic perspectives of information management, adoption and diffusion theory, information technology and organizational design, and how research methods are employed in information systems research. Students will gain an understanding of what theory is and how to develop and evaluate theory in the area of information management and information systems. Prerequisites: doctoral student standing or permission of the instructor. Fall term.

MGMT-6140 Information Systems for Management
Analyzes the use of information and communications technology to improve performance and to achieve organizational goals. Examines information systems in sales, marketing, finance, and operations. Provides a framework for understanding and evaluating IS contributions to product services and managerial effectiveness. Focuses upon implementation of information technology as a strategic weapon for productivity and competitive advantage. Lectures, case discussion, projects, and technical supplements. Prerequisites: familiarity with spreadsheet and database software. Spring term annually.

MGMT-6160 New Ventures
As the capstone course in the entrepreneurship concentration, this course challenges students to identify critical issues facing entrepreneurs in both startup and operational situations and to develop a course of action. The classes alternate between case studies and guest speakers who have lived the issues of the case. Selected readings build a base of knowledge about the legal and financial issues surrounding the creation and growth of new ventures. Prerequisite: MGMT-6620. Spring term.

MGMT-6170 Advanced Systems Analysis and Design
This is an advanced course in systems analysis and design that presents conceptual material about both traditional approaches to systems development such as process-oriented and data-oriented methodologies and evolving approaches such as object-oriented development methods. Key stages of the systems development life cycle including planning, analysis and design are the focus of this course. Models and procedures for understanding and modeling an organization's existing and planned information systems are presented. Computer-aided software engineering tools are used to provide hands-on experience in designing information systems. A case-based approach is used to provide students an opportunity to apply the analytical and design techniques covered in the course. In addition, students are expected to do a real-life systems development project. The course also focuses on the issues and challenges in managing systems development. (Cross listed as DSES-6550). Prerequisite: MGMT-6140 or equivalent. Fall term.

MGMT-6180 Strategic Information Systems Management
Information technology (IT) is a strategic asset that is being used to mold competitive strategies and change organizational processes. As IT and its uses become more complex, developing strategies and systems to deliver the technology has become more difficult. The net result is a growing need for guidance on the issues, strategies, and tactics for managing the use of information technology. This course is designed to partially fulfill this need and to enable students to integrate concepts and theories learned in previous IT courses. Prerequisite: MGMT-6140. Spring term.
MGMT-6190 Financial and Managerial Accounting
The nature and role of finance; the financial system; accounting for financial activities; valuation concepts and the balance sheet; revenue recognition, cost determinants, and the income statement; financial planning and budgeting; the cash budget, statement of sources and uses of funds, and pro forma statements; capital budgeting under certainty, project evaluation, and selection; profit planning and break-even analysis; fund accounting for governmental and nonprofit organizations. Fall term annually. 3 credit hours

MGMT-6200 Marketing and the WWW
This course discusses how the World Wide Web and electronic commerce are transforming marketing practices in business-to-business and business-to-consumer arenas. In business-to-business marketing, we can examine the different revenue-based and user-based Web business models; e-commerce as the direct marketing model; and the effect of disintermediation/reintermediation on traditional channels of distribution. On the business-to-consumer marketing side, we will discuss the characteristics of the online consumers, virtual communities, online support, and service and quality. Prerequisites: MGMT-6510 or a graduate level marketing/product management course, or permission of the instructor. Fall and spring terms. 3 credit hours

MGMT-6210 Manufacturing Accounting and Control Systems
This course focuses upon the analysis, control, and prediction of manufacturing technology, process, and product costs. Topics include standard costing and variance analysis, joint manufacturing costs, quality costs, performance measures for JIT and CIM/ FMS environments, divisional performance measures, and cost justification of new technologies. Prerequisite: MGMT-6190. Spring term. 3 credit hours

MGMT-6240 Financial Trading and Investing
This course introduces interactive trading in financial instruments. Students learn the principles of asset price discovery through real-time trading in a variety of markets, including equities, bonds, options, derivatives. Topics addressed include asset valuation, portfolio management and risk management in the context of real-time trading of financial instruments. The course uses the facilities of the Lally School’s Virtual Trading Room. Students will work in teams of two in many trading assignments. Prerequisites: MGMT-6310 and at least one other higher-level MBA, or two higher-level undergraduate finance courses or permission of the instructor. Spring term. 3 credit hours

MGMT-6250 Financial Theory and Its Links to Behavioral Sciences
This course addresses the behavioral sciences background of modern finance theory; the inclusion of risk and future uncertainty in general economic equilibrium; efficient markets; investor utility, objectives, and behavior; rational expectations and prospect theory; asset pricing in the context of general economic equilibrium; transaction costs, markets and institutions; information asymmetry and agency theory; capital structure and corporate finance. Other topics will be selected from corporate governance; futures and options; international exchange and risk management. The topics dealt with in depth will vary as the content responds to important issues in the field. Prerequisites: doctoral student standing or permission of the instructor. Spring term. 3 credit hours

MGMT-6290 Macroeconomic and International Environment of Business
This course identifies and analyzes major forces acting on the enterprise from the macroeconomic and international environment. Key factors include national income and output, interest rates, economic growth and business cycles, international trade and the balance of payments, exchange rates, monetary and fiscal policy. Factors are analyzed in terms of their impact on the economic and technological decisions of the enterprise. Lecture and recitation. Prerequisite: MGMT-6300. 3 credit hours

MGMT-6300 Business Economics
This course is an introduction to the economic environment in which a manager operates. Elements of this environment include the concepts of marginality and the trade-offs among conflicting goals. Microeconomic dimensions include cost and production theory, demand theory, and market theory. The macroeconomic elements of importance include the relations among gross output, income, and employment, and the effect of governmental economic policy on the operations of the firm. Fall term annually. 3 credit hours

MGMT-6310 Financial Management and Valuation of Firms
This course develops a working understanding of the major investment and financial decisions of the firm with emphasis on the role of technological change in financial decision making. Topics include net present value and its application, capital budgeting, corporate financing decisions, venture capital financing, debt policy and the interaction of investment and financing decisions, portfolio theory and capital asset pricing, capital budgeting (uncertainty), options and their application to technological choice. Prerequisite: MGMT-6190 and MGMT-6300. Spring term annually. 3 credit hours

MGMT-6320 Investment Analysis I
Introduction to investment instruments and modern methods of pricing them. Basic components of viable investment programs are outlined. Topics include expected utility theory and risk aversion, modern portfolio theo-
ry, equilibrium in capital markets (CAPM, APT), index models, futures and options, theory of active portfolio management. Prerequisite: MGMT-6310. Fall term.  

3 credit hours

MGMT-6330 Investment Analysis II
Advanced study in investment analysis, decision making, and practice. Emphasis on bond market analysis and bond portfolio management, including asset-backed securities, high-yield bonds, venture capital, and derivative securities. Topics include bond pricing, the term structure and risk structure of interest rates, duration concepts and immunization strategies, analysis of embedded options in fixed income securities. Application of strategies to real data set. Prerequisites: MGMT-6320 or permission of instructor. Spring term.  

3 credit hours

MGMT-6340 Financial Markets and Institutions
Focus on financial markets, new instruments and techniques for financing, risk management and its application to financial institutions. Overview of U.S. financial system, the Federal Reserve system, and monetary policy. Emphasis on impact of technology on securities markets and banks. Discussion of current issues in securities markets and banking, such as securitization, financial derivatives, junk bonds, bank failures, mergers and acquisitions, and international banking. Prerequisite: MGMT-6310. Fall term.  

3 credit hours

MGMT-6350 International Business
An integrated course on the international aspects of the modern corporation emphasizing the basic principles of international trade, investment decisions, and the operational management of an established multinational enterprise. The strategies necessary for competing in global markets. The course will provide students with an understanding of business decision making in a global environment. Prerequisite: MGMT-6310 or permission of instructor. Spring term.  

3 credit hours

MGMT-6360 International Finance
Course analyzes trends and themes in international financial management, especially how financial management and corporate strategies are carried out in international environments. Topics include foreign exchange markets and risk management, analysis of operating and transaction exposure, international financial markets and banking, international financing and investment. Working capital management and capital budgeting of multinational corporations. Case studies are used. Prerequisite: MGMT-6310. Spring term.  

3 credit hours

MGMT-6370 Derivatives Markets
Institutional structure of the markets for derivatives, hedging and basis risk, interest rate, and stock-index derivatives with financial management applications. Introduction to options, rational option pricing restrictions, binomial option pricing model, put and call option strategies. Prerequisite: MGMT-6310, Corequisite: MGMT-6320. Spring term.  

3 credit hours

MGMT-6380 Advanced Corporate Finance
The overall objective of this course is to study advanced corporate finance issues and test empirically the stock market reaction to financing decisions and the issuance of securities. Corporate finance topics include shareholder value and economic value added concepts, as well as corporate governance issues. Financing decisions include venture capital and initial public offerings, seasoned equity offerings, stock splits, corporate bonds and bank loans, stock listings on foreign exchanges. Other topics are mergers and acquisitions, pension fund management, financial analysis and planning. Real stock prices and case studies are used to apply the theoretical concepts. Prerequisite: MGMT-6310. Fall term.  

3 credit hours

MGMT-6400 Financial Econometrics Modeling
This course addresses financial modeling as an empirical activity. Several key issues and assumptions of finance are addressed through empirical modeling. Topics may include asset pricing, event studies, exchange rate movements, term structure of interest rates, and international linkages among financial markets. Computers are used extensively both in and out of class. Prerequisites: students should have taken at least two finance courses and MGMT-6100.  

3 credit hours

MGMT-6450 Manufacturing Systems Management
An overview of how product and service requirements are translated into manufacturing facilities, procedures, and organizations. The control systems considered include demand forecasting, inventory planning, production scheduling, quality control, MRP, and project control. In addition, a management perspective is used to examine decisions having a long-term manufacturing impact: capacity planning, location, and distribution, manufacturing processes, factory layout and factory focus. The course concludes with an introduction to manufacturing policy. Fall term.  

3 credit hours

MGMT-6470 Management of Quality, Processes, and Reliability
This course provides in-depth coverage of the quality management field by covering many of the qualitative, management aspects of quality, as well as some of the traditional quantitative measurement and control techniques. The emphasis is on the application of the quality principles to develop an understanding of concepts in quality and apply these concepts in problem solving situations. Six-Sigma methodology is highlighted. Some coverage of international considerations, via ISO-9000, and reliability topics is given. The aim will be to show students how companies have found solutions to problems and improved their
processes, products, and services using quality management concepts. Prerequisites: DSES-6110 and DSES-6230 or equivalent. (Cross listed as DSES-6170. Students cannot obtain credit for both this course and DSES-6170.) Full term annually. 3 credit hours.

MGMT-6480 Service Operations Management
This course discusses the role of services in an economy, managing services for competitive advantage, structuring the service enterprise, managing service operations, service productivity, quality, and growth. (Cross listed as DSES-6480. Students cannot obtain credit for both this course and DSES-6480.) Spring term. 3 credit hours.

MGMT-6490 Competitive Advantage and Operations Strategy
This course includes topics such as manufacturing as a competitive weapon; management of quality; manufacturing technology implementation; strategic impact of advanced manufacturing technologies; and manufacturing’s role in new product development. Spring term. 3 credit hours.

MGMT-6510 Design, Manufacturing, and Marketing I
First of a two-semester sequence that follows the flow of activities within companies that leads to the creation and distribution of new products. Emphasis on identification of consumer needs, product design, manufacturing processes, and issues required to launch the product. Integration across the disciplines of marketing, design, and manufacturing because the challenge in companies competing in global markets is to break down the barriers among the traditional functions. Two-semester team project. (Students cannot obtain credit for both this course and MGMT-6560). Fall term annually. 3 credit hours.

MGMT-6520 Design, Manufacturing, and Marketing II
This course continues the new product development process from MGMT-6510 with a focus on cost analysis and the implementation of a field based project to design and commercialize a new product. Measures of post-introduction performance are also considered. Continuation of two-semester team project. (Students cannot obtain credit for both this course and MGMT-6560). Prerequisite: MGMT-6510. Spring term annually. 3 credit hours.

MGMT-6530 Business-to-Business Marketing and Sales
Principles of marketing and selling in a business-to-business setting. The course introduces students to the concepts, analytical tools, and techniques applicable to the development of business marketing strategies. Marketing topics include segmentation, intelligence, channel/distribution strategies, product planning, organizational buyer behavior, using the Internet, advertising/promotion, and pricing. Sales topics include relationship selling, identifying prospects, dealing with objections, the closing process, follow up, and sales management. Prerequisites: MGMT-6510 and MGMT-6520 or equivalent. Spring term. 3 credit hours.

MGMT-6540 Marketing Communication and Promotion Strategy
Advanced study of the promotion management process including market situation analysis, media selection, spending plans, copy strategy, and advertising research methods. The focus is on integrating promotion strategies with buyer needs, product conceptualization, distribution strategies, and new communication technologies. Prerequisites: MGMT-6510 and MGMT-6520 or permission of instructor. Spring term. 3 credit hours.

MGMT-6550 Marketing Research
Marketing strategy decisions are developed in the framework of many case studies. Marketing research techniques, including questionnaire development and data analysis, are introduced and utilized in a team project. Prerequisites: MGMT-6510, MGMT-6520, and MGMT-6100. Summer and fall term. 3 credit hours.

MGMT-6560 Managing New Product Development
This course focuses on the basics of new product development. Using multimedia and interactive learning materials and simulations, students get an understanding of the importance of the integration of design, manufacturing, and marketing. Prerequisites: access to a computer with CD-ROM and Internet access. (This course is not for students taking MGMT-6510 and MGMT-6520. Students may not apply this course and MGMT-6510 and/or MGMT-6520 to their plan of study due to content overlap.) Fall term. 3 credit hours.

MGMT-6570 Consumer Behavior/Product Design
Topics in this course include the motivations and factors that shape consumers’ purchasing decisions and the perceptual process and how it affects consumer behavior as well as consumer reaction to product designs. The relationship between perception and product design is extended to topics such as design for understanding, universal product design, aesthetics, and industrial design. Prerequisite: MGMT-6510 or equivalent or permission of instructor. Spring term. 3 credit hours.

MGMT-6580 Marketing High-Tech Products
This course deals with the peculiarities of marketing products and services in high-tech environments. High-tech environments are characterized by high dynamism, high uncertainty, and compressed time cycles. The course consists of case studies, computer simulations, and a team project. Prerequisites: MGMT-6510, MGMT-6520, or any previous marketing course or permission of instructor. Spring term annually. 3 credit hours.

MGMT-6590 Marketing Strategy
Advanced study of the promotion management process including market situation analysis, media selection, spending plans, copy strategy, and advertising research methods. The focus is on integrating promotion strategies with buyer needs, product conceptualization, distribution strategies, and new communication technologies. Prerequisites: MGMT-6510 and MGMT-6520 or permission of instructor. Spring term. 3 credit hours.
MGMT-6590 Commercializing Advanced Technology
This course teaches MBA students the principles, skills and managerial challenges associated with identifying opportunities associated with novel, early phase technologies, developing value propositions that result from them, and nurturing them to a successful outcome. Prerequisite: MGMT-6510. Spring term annually. 3 credit hours

MGMT-6600 Research and Development Management
The course deals with the responsibilities of and operating problems faced by managers of research and development. The following areas are included: technology forecasting, technology planning, selection and evaluation of R&D projects, resource allocation, planning, control, and measuring results of R&D. Particular attention is given to creative problem solving, motivating and managing creative individuals, barriers to innovation, and organization alternatives for R&D, including matrix and project organizations. Spring term. 3 credit hours

MGMT-6610 Global Strategic Management of Technological Innovation
The course helps develop an understanding of and the method for managing technology as a strategic resource of the firm. In doing so, an understanding of the process, roles, and rewards of technological innovation are developed. Integrating the strategic relationship of technology with strategic planning, marketing, finance, engineering, and manufacturing are covered. Governmental, societal, and international issues are briefly covered. The course uses a variety of cases, readings, reports, and lectures. (Cross listed as DSES-6470; students cannot obtain credit for both this course and DSES-6470). Fall term. 3 credit hours

MGMT-6620 Principles of Technological Entrepreneurship
An introductory graduate course in initiating new technology-based business ventures and developing them into self-sustaining and profitable enterprises. Examines the process whereby a person decides to become an entrepreneur, screens opportunities, selects an appropriate product/market target, and obtains the necessary resources. Provides the theoretical and practical knowledge for the preparation of formal business plans. Prerequisites: MGMT-6190, MGMT-6310. Fall term. 3 credit hours

MGMT-6630 Starting Up A New Venture
An understanding of the critical issues related to starting up a new business is gained through team-based experiential learning. Small teams of students develop a comprehensive business plan that can be used to raise money for a new or relatively new venture. The experiential learning process is enhanced through team meetings with faculty and/or course advisers and through oral presentations to the entire class. Prerequisite: MGMT-6620. Spring term. 3 credit hours

MGMT-6640 Invention, Innovation, and Entrepreneurship
Creativity is the starting point for technological entrepreneurship. Through interaction with faculty and guest speakers, students increase their understanding of the creative process and some of the tools that can be implemented to stimulate and/or manage individual and collective creativity. In addition, through application of these techniques in course activities, students explore and attempt to enhance their own creativity. Fall term. 3 credit hours

MGMT-6650 Technology and Competitive Advantage
A capstone sequence in policy and strategy aimed at developing students’ understanding of the relationship between business strategy and technology. The process of converting technological opportunity into competitive advantage is viewed from the perspective of both large, established companies and new ventures. Prerequisite: course is taken towards the end of the program. Fall term annually. 3 credit hours

MGMT-6660 Strategy, Technology, and Global Competitive Advantage
This is part two of the two-course sequence that begins with MGMT-6650. This course is about strategy implementation and fundamental concepts in implementing strategy both at the corporate level and the business unit level. Prerequisite: MGMT-6650 or permission of instructor. Spring term annually. 3 credit hours

MGMT-6670 Practicum in Technological Entrepreneurship
Provides students with opportunities to learn, by practical fieldwork, how successful new technological ventures are created, developed, and financed. Students work in small teams with guidance from experienced entrepreneurs. Business plans are developed, and a formal report to a sponsoring company is required. Prerequisite: MGMT-6620. Spring term. 3 credit hours

MGMT-6680 Strategy, Technology, and Global Competitive Advantage
This course emphasizes the linkage between technology, strategy, and achieving global competitive advantage. This course develops the concept and practical tools of strategy, strategic planning, and implementation both at the business unit and at corporate levels. The strategies of technology-intensive international companies such as Intel, Microsoft, Netscape, Apple, Rhone-Poulenc, Toshiba, Xerox, MCI, ABB, and MapInfo are investigated and compared. The study of the evolution of General Electric’s strategies from 1970 to 2000 completes the course. Students work in teams to develop a 5-year strategic plan for a company or business unit of their choice, with a minimum of three strategic alternatives, and recommend the chosen alternative. This course cannot be taken by MBA students or taken with MGMT-6650 or 6660. Fall term annually. 3 credit hours
MGMT-6690 Supply Chain Management for E-Business
This course examines how the Internet and emerging e-business models are transforming the flow of products, information, and revenues across supply chains. It focuses on how inter-enterprise integration and value chain constellations can be deployed to effectively detect and fulfill custom needs in a cost-effective manner by eliminating traditional constraints in supply chain design, dislodging obsolete intermediaries, and creating new forms of value added intermediation. The role of exchanges and hubs in the procurement of industrial goods and services will also be examined in depth. Concepts will be discussed for different types of products such as physical goods, informational goods, and services. Students will develop the ability to conceptualize design and implement supply chains for e-business organizations. Prerequisites: Background in marketing or operations management and a background in information technology are required to enroll in this course. The background could have been obtained either through appropriate course work or through work experience. Full term annually. 3 credit hours

MGMT-6710 Designing, Developing, and Staffing High-Performance Organizations I
A year-long sequence concerned with different ways organizations change and learn in response to and utilizing technology. Taking a systems approach, implications on the organization and on people are considered with topics such as team building, motivation, communication, decision making, organizational design, staffing and selection, compensation, reward systems, evaluation, labor relations, and job design. The interface of initiatives such as business process redesign, continuous improvement, and information systems with people systems are themes of the course. (Limited to part-time MBA students). Summer term annually. 3 credit hours

MGMT-6720 Designing, Developing, and Staffing High Performance Organizations II
A continuation of the year-long sequence that begins with MGMT-6710. Prerequisite: MGMT-6710. Spring and summer terms annually. 3 credit hours

MGMT-6730 Technological Change and International Competitiveness
Analysis of the differences among technical systems and interactions with industrial growth is undertaken with regard to nation states, industrial sectors, and companies. To develop tools of analysis regarding technological change, industrial policy, and corporate performance. The impact of technological change on industrial growth and competitiveness is viewed from three perspectives: the general manager, the technical professional, and the public official. Fall term. 3 credit hours

MGMT-6740 Technology and Organization
This course explores our current understanding of the relationship between technological and organizational change. It draws on current research in management, engineering, science, and the humanities and social sciences to examine the diverse ways in which technology affects the character of organizational life and structure. 3 credit hours

MGMT-6750 Legal Aspects of E-Business and Information Technology
Legal, regulatory and public policy issues related to e-commerce/e-business, the Internet, and information technology are explored through an analytic, critical thinking approach. Topics include: e-contracts, digital signatures, B2B and B2C agreements; ownership, protection, and exploitation of intellectual capital including patents, trademarks, copyrights and trade secrets; regulatory issues; ISP and Web site liability including defamation; copyright infringement, securities regulation, and criminal acts; policy issues including privacy, security and encryption, and obscene materials. Global e-commerce will be explored. Full term. 3 credit hours

MGMT-6770 Complex Organizations and Organization Theory
A macro approach to understanding organizations. Topics include organizational design, contingencies of design, organizational processes, such as culture, environmental interfaces and influences, information processing approaches to design, decision making, and organizational change and development. Prerequisites: MGMT-6710 and MGMT-6720 or permission of instructor. 3 credit hours

MGMT-6800 Ethical, Political, and Legal Context of Business
Issues and forces of the environment of business including social and cultural, public policy and legal, technological, economic, physical, and international. Changing environment and pressures upon business. Managerial ideology and practices. Values and ethics. Technology: history of innovation, productivity, assessment, societal effects. Business and government relationships; legal framework of business. Corporate governance and management. Relations with the various constituencies of the business firm. Fall, spring, and summer terms annually. 3 credit hours

MGMT-6810 Management of Technical Projects
The purpose of this course is to enable the technically oriented manager to select projects of value to the organization, develop a project plan including staffing, perform a risk analysis on the project, and successfully execute the project. Students, working alone or in teams, practice the project management process by planning a current project in the area of new product development, process reengineering, information systems or any other project with business implementation. Fall term. 3 credit hours
MGMT-6820 Communications in Organizations
Covers the skills and techniques in effective communications in organizations, including defining the problem and purpose of the communications, the audience, and the intended result. Introductory communications theory is covered; the focus is primarily on written communications, but limited coverage is given to oral techniques, visual representations, and the like. Students prepare and are critiqued on various forms of communications in organizations. 3 credit hours

MGMT-6840 Practicum in Management
This practicum provides students with the opportunities to put their knowledge to work in a field project in their area of concentration, including entrepreneurship, finance, marketing, information systems, production and operations management, environmental management policy. Projects are conducted in collaboration with companies in the Rensselaer Incubator Center, the Technology Park, and the Capital Region. Project teams make presentations before a panel. Prerequisite: all first year MBA courses and faculty adviser approval. 3 to 6 credit hours

MGMT-6850 Environmental Management and Policy
Documents, assesses, and explains recent changes in executive positions, programs, and tactics concerning environmental management. Topic areas include environmental audits and quality assurance programs, regulatory compliance and corporate strategy, community right-to-know initiatives, relation of energy planning to environmental externalities. This course satisfies an EMP core requirement and is open to all MBA students and graduate engineers. Spring term. 3 credit hours

MGMT-6860 Environmental Disputes Management
Applies the field of conflict resolution to environmental disputes. Topics include nature of entrenched parties, role of public entities, lessons from hazardous waste disputes, models of resolving disputes, the case of global warming. Fall term. 3 credit hours

MGMT-6870 Managing Environmental Law
To give the private-sector manager the skills to deal with transactions that involve environmental law. Intended for nonlawyers who want an appreciation for how legal issues should be factored into corporate decision making. While the course will provide an overview of environmental law as a discipline, its principal focus is to develop practical skills. Spring term. 3 credit hours

MGMT-6880 Management of Environmental Technology
The challenge facing environmental managers today is how to use their understanding of nature and appropriate technology to protect and revitalize natural systems. This course gives students a comprehensive view of trends in technology application and regulation and environmental debates by the people making environmental policy. Oral presentations required. Fall and spring terms. 3 credit hours

MGMT-6900 Doctoral Research Methods I
The objectives of this beginning doctoral course are to introduce students to social science theory development, expose students to a broad array of research techniques, and help students design research programs and write about them. We review the underpinnings of scientific theory and a range of quantitative and qualitative research methods. Drawing on their own interests, students write one research proposal and two research papers illustrating the application of two different research methodologies. Spring term annually. 3 credit hours

MGMT-6910 Doctoral Research Methods II
This course develops empirical tools and their applications to key areas of business analysis, including finance, human resource analysis, marketing, organizational behavior, and production appropriate theories. Empirical techniques emphasized include advanced regression and structural equations methods. Specialized statistical tools will be used. Prerequisite: MGMT-6900. Fall term annually. 3 credit hours

MGMT-6920 Strategic Management Theory Seminar
This is a reading course designed to introduce first year Ph.D. students in management to the theory families and empirical research in the field of Strategic Management. Strategic Management theories draw from parent disciplines of economics, psychology, sociology, anthropology, evolutionary biology, and political science. This puts the field at the nexus of all management studies. Prerequisites: doctoral student standing, Doctoral Research Methods sequence or permission of doctoral program director. Fall term. 3 credit hours

MGMT-6940 Independent Study
1 to 6 credit hours

MGMT-6960 Topics in Management
3 credit hours

MGMT-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned.
by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

**MGMT-9990 Dissertation**
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  

**MTLE Materials Science and Engineering (SOE)**

**MTLE-2020 Introduction to Ceramic Materials**

**MTLE-2100 Structure of Engineering Materials**
The first course in Materials Science and Engineering. Structures of metals, ceramics, and polymers and experimental techniques for their determination are discussed. Laboratory experience is included. Prerequisite: ENGR-1600 or equivalent. Spring term annually.  

**MTLE-2940 Readings in Materials**
Spring term.  

**MTLE-2980 Senior Project**
Spring term.  

**MTLE-4030 Glass Science**
Glasses are used in optical communications (optical fibers), electronics (insulator and substrate), and nuclear waste processing in addition to conventional use as windows, light bulbs and containers. Subjects covered include: Formation and structure of inorganic glasses. The relationship between properties and cooling rate. Viscosity and structural relaxation. Phase separation and crystallization. Ionic diffusion and electrical properties. Mechanical strength and fatigue. Glass surface and chemical durability. Optical properties. Fall term.  

**MTLE-4050 Introduction to Polymers**
A first course on polymer physics and structure-property relationships. Topics include molecular structure; morphology of amorphous and crystalline polymers; physical properties of polymers in relation to structure, including rubber elasticity, viscoelasticity, and glass transition; mechanical testing. This is a companion course to CHEM-4620 Introduction to Polymer Chemistry. Course is open to advanced juniors, seniors, and graduate students in science or engineering and others by permission of instructor. Fall term.  

**MTLE-4100 Thermodynamics of Materials**
Rigorous development of classical thermodynamics as applied to prediction of materials properties. Nonideal gases, solutions, phase equilibria, chemical equilibria, defects. Prerequisites: ENGR-2250, CHEM-1300, ENGR-1600 or equivalent. Fall term annually.  

**MTLE-4150 Kinetics in Materials Systems**
Kinetic processes in materials. Overview of kinetics in relation to equilibrium thermodynamics, atomistics and mathematics of diffusion, phase transformations, and microstructural evolution. All materials classes, including metals and alloys, ionic and intermetallic compounds, glasses, semiconductors, and polymers, will be considered in terms of similarities and differences. Includes laboratory component. Prerequisites: MTLE-4100, CHEM-1300, ENGR-1600. Spring term annually.  

**MTLE-4160 Semiconducting Materials**
Review of electronic properties of materials. Growth and structure of semiconductors. Diffusion, ion implantation, oxidation, microlithography, plasma etching, thin film deposition, metallization, with emphasis on Si technology. Introduction to compound semiconductors. Students cannot obtain credit for both this course and ECSE-4250. Prerequisite: MTLE-4200 or equivalent. Spring term.  

**MTLE-4200 Properties of Engineering Materials I**

**MTLE-4250 Properties of Engineering Materials II**
This is a required departmental course, but is also appropriate for biomedical engineers and other engineering disciplines as an elective. This course teaches the mechanical properties of metals, ceramics, and polymers from both the macroscopic and atomistic or micromechanical viewpoints. An introduction to three-dimensional stresses and strains. Elastic behavior, plastic behavior, strengthening mechanisms, fracture, creep, and fatigue are all addressed. Includes laboratory component. Prerequisites: ENGR-1600, MTLE-2100. Spring term annually.
MTLE-4290 Electronic Packaging
Design and fabrication of interconnection structures in electronic systems; heat transfer and mechanical and environmental protection; applications, future trends, and limitations. (Cross listed as ECSE-4290 and MANE-4290. Students cannot receive credit for both this course and either ECSE-4290 or MANE-4290.) Prerequisites: senior or graduate level at Rensselaer or an undergraduate degree in engineering or science. Fall term. 3 credit hours

MTLE-4310 Corrosion
Mechanisms, characteristics, and types of corrosion. Methods for testing, combating, and evaluating corrosion resistance. Suitability of metals, ceramics, and organic materials in corrosive environments. Oxidation and other high-temperature gas-metal reactions. Spring term. 3 credit hours

MTLE-4400 Materials Synthesis and Processing I
Emphasis is on materials synthesis, with four instructional modules drawn from aspects of melt and extractive metallurgy and from the synthesis of polymers, ceramics and glasses, electronic materials, composite materials and nanophase materials. Prerequisites: MTLE-4200, MTLE-4150, MTLE-4250. Fall term annually. Includes laboratory experience. 4 credit hours

MTLE-4410 Welding Processes and Metallurgy
Fundamental principles, primary variables, and metallurgical changes associated with both fusion and nonfusion welding processes. Energy sources, rates and modes of energy transfer to the work, and distribution of energy in the work as these affect plastic softening or melting, plastic flow or solidification, post-solidification transformations, heat-affected zone microstructures, residual stresses and distortion, defect formation, and resultant properties; attention to the effects of weldment material, joint design, process, and procedural variables. Physical metallurgy is emphasized throughout. Practical examples highlight theory. Hands-on laboratory exercises complement lectures. Prerequisite: ENGR-2010 or ENGR-1600. Fall term. 3 credit hours

MTLE-4420 Joining of Advanced Materials
Individual joining processes including mechanical fastening, adhesive bonding, welding, brazing, soldering, thermal spraying, and variants or hybrids of these. Advantages and disadvantages, mechanisms for attaining joint strength, various specific methods and procedures, joint design and analysis, expected properties, practical issues in production, safety, and economics, and special problems with each process. Joining of similar and dissimilar combinations of metals and alloys, intermetallics, ceramics, glasses, polymers, and composites, with special attention to attaining optimum properties. Team term project. Prerequisites: ENGR-1600 and ENGR-2010. Fall term. 3 credit hours

MTLE-4450 Materials Synthesis and Processing II
Emphasis is on materials processing, with four instruction modules drawn from aspects of casting and molding, deformation processing, powder processing, joining and additive processes, cutting and removal processes, and annealing/heat treatment processes. Includes laboratory component. Prerequisite: MTLE-4400. Spring term annually. 4 credit hours

MTLE-4630 Composites Laboratory
Fabrication and characterization of composite materials and structures. Characterization techniques include strength, stiffness, adhesive shear strength, coefficient of thermal expansion, and differential thermal analysis. A short design project involving a composite structure is carried out. Laboratory sessions are complemented by a weekly lecture. Prerequisite: ENGR-1600. Spring term. 3 credit hours, 5 contact hours

MTLE-4910 Design in Materials Engineering
Basic design concepts and the underlying structure-property-process-performance interaction. Engineering materials, structures and properties, principles and process of materials selection, generation of materials performances indices, assessment and optimization of performance, processing routes and manufacturing issues, role of reverse engineering and failure analysis in design are covered. Generic design against yielding, fracture, flexure, buckling, fatigue, creep, corrosion, and wear are addressed, as opposed to design of specific products or in specific areas. A semester-long team design project is a principal focus. Team-building and leadership skills are developed. Nontechnical issues of environmental impact, cultural and societal impact, safety and health, ethics, and cost are discussed. Writing assignments and oral reports develop communication skills. Enrollment for MS&E majors is restricted to seniors or graduates. Prerequisite: CHEM-1300 and ENGR-1600 or ENGR-2010. Fall term annually. 3 credit hours

MTLE-4920 Applications of Materials
A capstone experience to afford seniors in MS&E the unique and invaluable opportunity to participate as a vital member of a truly multidisciplinary design team (comprised of engineering students from other disciplines, as well as MBAs) and function just as they will as professionals in practice, in preparation for practice. The course revolves totally around a design project, focusing on the structure - property - process - performance interaction underlying all design, with no homework or exams; just memos on progress, individual and group meetings with the instructor, conceptual design report, project notebook or journal, and final report. Prerequisite: satisfactory completion of MTLE-4910. Spring term annually. 2 credit hours
MTLE-4960 Topics in Materials Engineering  
Spring term annually.  
3 credit hours

MTLE-6010 Defects in Solids  
Point defects, nonstoichiometry, diffusion and defects, electronic defects, elastic properties of dislocations, dislocation-point defect interactions, dislocation arrays, grain boundaries, stacking faults, phase stability, twin boundaries, epitaxial interfaces. Prerequisite: MTLE-2100 or equivalent. Fall term.  
3 credit hours

MTLE-6030 Advanced Thermodynamics  
Review of classical thermodynamics. Development of basic concepts of statistical thermodynamics. Application of both classical and statistical techniques to the determination of phase and chemical equilibrium in real systems. Prerequisite: MTLE-4100 or equivalent. Fall term.  
3 credit hours

MTLE-6040 Principles of Crystallography and X-Ray Diffraction  
Symmetry operations, point groups and space groups, X-ray and electron diffraction techniques, reciprocal lattice, Ewald sphere, mathematics of diffraction, crystal chemistry, crystal structure-property relationships. Spring term.  
3 credit hours

MTLE-6060 Kinetics of Materials Reactions I  
3 credit hours

MTLE-6080 Electron Microscopy of Materials  
Introduction to electron optics, electron diffraction contrast mechanisms, specimen preparation, and microanalysis. Theory and operating fundamentals of the SEM, TEM, STEM, and the electron microprobe. Analysis of images from crystalline materials using kinematical and dynamical theories of electron diffraction. Prerequisite: MTLE-4100 or MTLE-6030 or equivalent. Fall term.  
3 credit hours

MTLE-6100 Advanced Electron Microscopy  
The theory and practice of image interpretation in transmission electron microscopy, including kinematical and dynamical theory of electron diffraction, contrast analysis of defects, lattice and structure imaging, convergent beam diffraction. Prerequisite: MTLE-6040 or equivalent. Spring term.  
3 credit hours

MTLE-6110 Diffusion in Solids  
3 credit hours

MTLE-6150 Fracture of Solids  
3 credit hours

MTLE-6220 Advanced Semiconducting Materials and Processing  
Discussion of selected advanced and emerging topics in microelectronics materials and fabrication. These may include metallization, thin film deposition, interconnection technology, microlithography, plasma etching and processing.  
3 credit hours

MTLE-6300 Integrated Circuit Fabrication Laboratory  
Theory and practice of IC fabrication in a research laboratory environment. Test chips are fabricated and the resulting devices and circuits evaluated. Processes and fabrication equipment studied and used include oxidation/diffusion, CVD reactors, photolithography, plasma etching, vacuum evaporator, ion implantation, etc. Instruments used in process monitoring and final testing include thin film profilometer, ellipsometer, resistivity probe, scanning electron microscope, capacitance-voltage system, etc. The fundamentals of hazardous material handling and clean room procedures are studied. (Cross listed as ECSE-6300. Students cannot obtain credit for both this course and ECSE-6300.) Prerequisite: ECSE-4250 or equivalent. Spring term annually.  
3 credit hours

MTLE-6350 Composite Materials  
Introduction to fiber-reinforced composites: atomistic basis for ultimate properties of solids; flaws and flaw distributions; shear-lag model for fiber/matrix stress transfer; predictions of composite strength and toughness as related to real material behavior. Preparation, advantages, and limitations of fiber reinforcements, and of polymer, metal, and ceramic matrix composites are discussed. Anisotropic continuum representations as well as test and characterization methods are introduced. Prerequisites: graduate standing in materials or consent of instructor. Fall term.  
3 credit hours

MTLE-6400 Vacuum Techniques  
3 credit hours
MTLE-6420 Surface Phenomena

MTLE-6430 Materials Characterization
Principles and applications of current techniques for the chemical, structural, and morphological characterization of engineering materials, with an emphasis on materials used in the microelectronics industry. Techniques studied include various electron and ion microscopies, and diffraction techniques. Fall term odd-numbered years. 3 credit hours

MTLE-6450 Melting and Solidification

MTLE-6610 Deformation Processing
Mechanical metallurgy and mechanics of the classical metal-working operations. Analytical techniques. Friction and lubrication. Workability. Effects on as-worked properties. Technological discussions of forging, rolling, extrusion, drawing, and other unit operations. Prerequisite: ENGR-1600 or equivalent. Spring term. 3 credit hours

MTLE-6750 Special Topics in Ceramics
A course in physical ceramics, the content of which will be modified in accordance with current interests and technology. Spring term. 3 credit hours

MTLE-6830 Deformation of Materials and Rheology
A course intended to acquaint the student with the phenomenological description of constitutive equations for solids and melts. The necessary background material on stress tensors, strain tensors, rate-of-deformation tensors, invariants, principal axes, and isotropic and deviatoric tensors is fully developed. Specific applications include the linear elastic solid, the anisotropic elastic solid, the nonlinear elastic solid, the viscoelastic solid, creep, relaxation, yielding, viscoelastic fluids, and viscometric flows. The required mathematics background is a course in linear algebra (matrices) or equivalent. Fall term. 3 credit hours

MTLE-6840 Polymer Engineering
Survey and engineering analysis of industrial processes and commercial polymers. Topics include introductory fluid mechanics, non-Newtonian fluids, molecular theory of viscoelasticity, analysis of extrusion and other selected processes. Open to all graduate students majoring in polymer science and engineering. Spring term. 3 credit hours

MTLE-6900 Graduate Seminar
Fall and spring terms annually. 0 credit hours

MTLE-6930 Literature Study
A special course assignment open to graduate students working toward a master's degree. Applicable where a student cannot reasonably arrange to submit a thesis. A written report on the study must be submitted and defended before a committee of the faculty. 1 to 3 credit hours

MTLE-6940 Materials Engineering Project
3 credit hours

MTLE-6960 Topics in Materials Engineering
3 credit hours

MTLE-6970Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A,B,C, or F are assigned by the faculty adviser at the end of the semester.  If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

MTLE-6980 Master's Project
Active participation in a master's-level project under the supervision of a faculty adviser, leading to a master's project report. Grades of IP are assigned until the master's project has been approved by the faculty adviser. If recommended by the adviser, the master's project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

MTLE-6990 Master's Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

MTLE-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly
defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.

Variable credit hours

NSST Natural Science for School Teachers

NSST-4110 Introduction to Instructional Technologies
This course is designed to improve high school mathematics and science education by enabling teachers to develop classroom materials using modern instructional technologies. Among specific topics are spreadsheets, data acquisition and visualization in computer-based labs, simulation, hyper- and multi-media, mathematical software, modern calculators. This course may not be used for credit in any program except the M.S. in Natural Sciences. Summer term. 4 credit hours

NSST-4120 Teaching with Technology
This course will continue the work of the preceding course, Introduction to Instructional Technologies, into the use of computer networks such as the World Wide Web, and a further exploration of the computer in laboratory science. Discussions will center on the best ways to apply instructional technologies to enhance the educational environment. Students will develop a philosophy of technology integration to guide them in the appropriate application of technology in the classroom. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4110. Summer term. 4 credit hours

NSST-4130 Nature of the Mathematical Sciences
Participants in this course will explore the nature of mathematics by working on a variety of mathematical problems including some questions which are considered open questions by most mathematicians. In addition, participants will consider the important role of mathematics as a tool in other areas of study, especially science. There will be an emphasis on important mathematical concepts, history, and applications that are suitable for use in secondary school classrooms. Emphasis will also be placed on methods of communicating mathematics and science as well as developing the mathematical and scientific abilities of young people. This course may not be used in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-4350 Engineering Math Methods and Physical Principles I
Mathematical skills are built through modeling of physical systems with a review of physical principles and the modeling and solution of basic engineering problems. This first course treats familiar physical phenomena, geometric relationships, force balances, conservation laws for fluid and electrical systems. Engineering software such as MatLab will be used. Studio course. Prerequisite: admission to the M.S. in Engineering Principles program. Summer term. 4 credit hours

NSST-4400 Foundations of Instruction and Learning in Secondary School Education I
Drawing from on-site secondary school classroom experiences in local schools, students are led to topics in educational and cognitive psychology, pedagogy in teaching mathematics and science, and history, philosophy, and sociology of education. Each week there will be at least 5 hours of field work required and 4 1/2 hours of a problem-solving seminar at Rensselaer. No prerequisites, but a course in general, cognitive, or adolescent psychology desirable. Restricted to students admitted to the Rensselaer Teacher Education program. Fall term annually. 6 credit hours

NSST-4410 Foundations of Instruction and Learning in Secondary School Education II
A continuation of NSST-4400. Students spend at least four hours per week working with teachers in the Troy School District and four hours each week in a problem-solving experience at Rensselaer. (Cross listed as PSYC-4430. Students cannot obtain credit for both this course and PSYC-4430.) Prerequisite: NSST-4400. Spring term annually. 6 credit hours

NSST-4420 Student Teaching in the Secondary School
As part of their academic requirements, students work full time as student teachers in a local secondary school classroom gradually taking on full-time teaching responsibilities in the content areas where teaching certification will be granted. Students are supervised by a local Mentor Teacher and by a Rensselaer faculty member or adjunct. Prerequisite: NSST-4410. Fall term annually. This course is offered on a satisfactory/unsatisfactory basis. 0 to 9 credit hours

NSST-4440 Student Teaching Seminar
Student teachers meet in a seminar once a week at Rensselaer to discuss their classroom teaching experiences and to reflect upon the relationship between their present student teaching experience and the previous year’s work. Prerequisite: NSST-4410. Corequisite: NSST-4420. Fall term annually. 3 credit hours

NSST-4450 Secondary School Instructional Materials Design
A reading or research course. Students work on state-of-the-art instructional technologies to produce innovative curriculum materials reflecting the subject content of the area where teacher certification will be granted. Prerequisite: NSST-4420. Spring term annually. 4 credit hours
NSST-4610 Nature and Processes of Natural Sciences
The content of this course will be drawn from the areas of motion, energy, electricity and magnetism, and the periodic table of the elements. Work will center around the great ideas in the physical sciences, with emphasis on conceptual development, historical background, and applications of interest at the secondary level. This course may not be used for credit in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-6120 Curriculum of the Future
This course represents the capstone of the instructional technologies strand of the program. Teachers will learn the design, production and implementation of fully interactive learning technologies. Various multimedia authoring tools will be discussed and their capabilities assessed for different educational purposes and technological feasibility in the teacher’s current school situation. Principles of instructional design, use of multi-sensory communication, techniques of story boarding and the use of interactive simulations in science and math education modules will be covered. Participants will gain hands-on experience with an advanced multimedia authoring tool as well as the preparation of a variety of media-graphics, animation, sound, and video. The final project will be the creation of a multimedia learning module which the teacher brings back for use in the classroom and/or on the World Wide Web. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4110, NSST-4120. Summer term. 4 credit hours

NSST-6130 Studying Teaching and Learning
Participants will study teaching and learning beginning with reflection on their own pedagogical practices and leading to an examination of perspectives on learning offered by developmental psychology, cognitive science, and instructional sociology. Students will refine their skills in analyzing social situations and diagnosing their student’s understanding and misunderstanding. A course project will involve students in comparing teaching and learning across a range of interactions, teaching contexts including their own classes, and interactive multimedia learning environments. This course may not be used in any program except the M.S. in Natural Sciences. Summer term. 3 credit hours

NSST-6210 Human Biology
The course will emphasize the application of basic cellular and physiological principles to human and higher mammalian organisms. An introduction to the neural, sensory, circulatory, renal, respiratory and hormonal systems will be included with an emphasis on the control and integration of these systems. The course format will include lecture and workshop activities with emphasis on the use of technology to enhance classroom experiences. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer term. 3 credit hours

NSST-6220 Science of the Environment
An introduction to a variety of ways to study the environment, especially through the cooperation of the humanities and the sciences, including both the social and the natural sciences. The course addresses the issue of sustainability by assessing the scale of human activities in relation to natural processes. Topics such as carrying capacity, social structure, biodiversity, energy, climate change, emergent diseases and social justice will be considered. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer term. 3 credit hours

NSST-6230 Biochemical Science
Fundamentals of biochemistry including the structure of proteins and protein complexes; mechanisms, kinetics, energetic, and regulation of enzymatic reactions; structure of lipids and cellular membranes; and introduction to metabolic pathways emphasizing carbohydrate metabolism. Taught in studio format which includes a mix of lectures, student use of computer-based interactive tutorials, and informal student-faculty interactions. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer. 3 credit hours

NSST-6240 Biomolecular Science
Course will describe the interactions at the molecular, cellular, and organ level of one or more biological processes, i.e., the immune response, antibody production, and cellular immunity. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer term. 3 credit hours

NSST-6260 Environmental Chemistry
A discussion of some important chemical processes in the environment, both those that occur naturally and those that result from human activities. Chemistry of the atmosphere, of aqueous systems, and of soils and rock will be included. Examples of topics include the chemistry of important elements (examples are biogeochemical cycles of carbon, nitrogen, and sulfur; toxic heavy metals such as mercury and lead), nuclear chemistry of natural and anthropomorphic origins, chemistry of petroleum, plastics, and other organic materials. This course may not be used in any program except the M.S. in Natural Sciences. 3 credit hours

NSST-6270 Principles of Modern Chemical Analysis
Much of modern chemical analysis is based on instrumental techniques. This course will consider the basic principles underlying some widely used methods and will include hands-on laboratory experience carrying out some
analytical procedures. Examples of methods to be included are atomic absorption spectroscopy, flame emission spectroscopy, visible-ultraviolet absorption spectroscopy, visible and X-ray fluorescence, gas and liquid chromatography. This course may not be used in any program except the M.S. in Natural Sciences.

**NSST-6280 Molecular Structure and Spectra**
Atomic and molecular structure will be discussed from the point of view of bonding and energy and how these relate to spectroscopic properties. Use of spectra for establishing the structure of molecules will be stressed. Some laboratory exercises will be included. This course may not be used in any program except the M.S. in Natural Sciences.

**NSST-6310 Mathematics of Discrete Processes**
Depending on the instructor, this course will introduce the student to, among other things, some fundamental concepts from graph theory and combinatorics and will address additional topics from a standard discrete mathematics course within the context of these content areas. There will be an emphasis on modeling real situations and testing intuition. The course seeks to stress pedagogically the process of doing mathematics as an ongoing process and to emphasize the importance of communication of questions, conjectures, and results in mathematics, both verbally and in writing and to model an environment in which inquiry-based learning plays an important role.

**NSST-6320 Dynamical Mathematics**
Students will be introduced to some fundamental concepts from discrete dynamics, including, among others, chaos theory, and will be urged to suggest and discuss applications of mathematics to several fields, such as epidemiology. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer term.

**NSST-6330 Geometry: Constructions, Theory and Applications**
Students will use one or more software packages to investigate the problems and explore the nature of the various geometries. Topics will be chosen from, among others, ruler and compass constructions and constructible number; history and famous problems in geometry; advanced Euclidean geometry; axiomatic approaches to geometry; transformations of the Euclidean Plane; convexity and applications. This course may not be used in any program except the M.S. in Natural Sciences. Prerequisite: NSST-4510, NSST-4310. Summer term.

**NSST-6960 Studying Teaching and Learning**
Participants will study teaching and learning beginning with reflection on their own pedagogical practices and leading to an examination of perspectives on learning offered by developmental psychology, cognitive science and interactional sociology. Students will refine their skills in analyzing social situations and diagnosing their students' understanding and misunderstanding. A course project will involve students in comparing teaching and learning across a range of interactional teaching contexts including their own classes and interactive multimedia learning environments.

**NSST-6970 Professional Project**
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

**PHIL Philosophy (HSSH)**

**PHIL-1110 Introduction to Philosophy**
An introduction to the major areas of philosophy (ethics, theory of knowledge, philosophy of religion, etc.) and to some of the main problems treated within these fields. Selections from contemporary as well as classical authors are studied and discussed. Students are encouraged to develop a disciplined approach to intellectual problems. Emphasis varies with the instructor. Fall and spring terms annually.

**PHIL-2130 Introduction to Philosophy of Science**
How does science stimulate philosophical thinking and how has philosophy influenced science? This broad range of interaction is studied with special attention given to the concepts of theory, observation, and scientific method. Special attention is given to issues basic to psychology, in particular, reductionism, behaviorism, functionalism, and cognitivism. (Cross listed as STSH-2130. Students cannot obtain credit for both this course and STSH-2130.) Spring term annually.

**PHIL-2140 Introduction to Logic**
Introduction to first-order logic as a tool to be used in engineering, computer science, philosophy, etc., and as procedural knowledge helpful in puzzle-solving environments (e.g., standardized tests). A hands-on laboratory component is included. No previous logic or math presupposed. Fall term annually.
PHIL-2150 Inspired Lives: Moral Exemplars and Visionaries
We focus on the character and conscience, teaching and deeds of reputed ethical exemplars. Everyday "local heroes" working in obscurity in our communities are highlighted alongside ethical superstars like Mother Teresa, Gandhi, or King. How do exemplars embody and function as models of character development and aspiration? What lessons can we draw from these exemplary lives for our workaday lives and personal reflections. Term: offered upon availability of instructor. 

PHIL-2220 Philosophy of Technology
How is life within our technosystem different from or similar to other forms of life that humans have lived or are possible? This is the guiding question for the course, with emphasis on environmental ethics and ecology. Readings come from both analytic and existentialist traditions in philosophy as well as current scholarship in psychology, sociology, and anthropology. Alternate years. 

PHIL-2300 Asian Philosophies
An introduction to the major Asian philosophical traditions. Comparisons between different Asian traditions and between Asian and non-Asian traditions as appropriate. Fall term annually. 

PHIL-2500 Bioethics
This course involves a philosophical analysis of some of the basic moral issues raised by recent and anticipated developments in the areas of biology and medicine. The general question "What are moral problems, and how does one resolve them?" is examined in the context of concrete cases involving issues such as abortion, euthanasia, organ transplantation, experimentation on human patients, cloning, genetic engineering, behavior control and modification. (Cross-listed as STSH-2500.) Spring term annually. 

PHIL-2600 Moral Development
An analysis of psychological research on how our commonsense moral beliefs develop from early childhood through old age and their application to daily problems. A major focus is on the conflict between themes of justice or individual rights and caring compassion and its relation to gender differences (the Kohlberg/Gilligan debate). (Cross listed as PSYC-2600. Students cannot obtain credit for both this course and PSYC-2600.) Annually. 

PHIL-2710 Sanity, Madness, and Society
An examination of the models of a human being associated with various theories of madness (e.g., the psychoanalytic theory), and of the structure of interpersonal relationships in such settings as the family and mental institutions. The social and ethical implications of saying that someone is mentally ill, together with the claim that there is no such fact as mental illness, are also examined. Readings are drawn from the work of such authors as Laing, Szasz, Goffman, Sartre, Bateson, and Freud. Offered on availability of instructor. 

PHIL-2830 Comparative Religion
What is religion? What are its origins? What are its essential practices? To answer these questions, different religious traditions-Judaism, Christianity, Islam, Hinduism, Buddhism, Confucianism, Taoism, and Shinto are studied in terms of their concepts of radical defectiveness, the sacred, ways of ultimate transformation, and human perfection. Fall term annually. 

PHIL-2940 Philosophy Studies
Independent study of a particular topic. Prerequisite: permission of instructor. 

PHIL-2960 Topics in Philosophy
Experimental courses on subjects to be announced in advance. 

PHIL-4220 Social and Political Philosophy
An exploration of such concepts as freedom, rights, and consent and their interrelationship; and a consideration of their bearing on questions of justice, law, and human welfare. Spring term annually. 

PHIL-4240 Ethics
A critical examination of traditional and contemporary works in ethical theory by considering what these theories have to say about how we should live, what rights and obligations we have, what things are intrinsically valuable. Typically this includes such topics as ethical and cultural relativism, egoism, freedom, and responsibility. Often the focus will be on contemporary issues such as war, abortion, equality, or punishment. Fall or spring term annually. 

PHIL-4260 Philosophy of Artificial Intelligence
This course may be roughly divided into two general areas: philosophical problems in AI and philosophical issues that arise because of AI. An example from the first area is the Knower Paradox, a paradox in which an apparently desirable formalism for handling an agent’s knowledge leads to inconsistency; an example from the second area is John Searle’s attack on so-called “Strong” AI by way of his Chinese Room argument, wherein he claims that because a computer at bottom just manipulates symbols it cannot genuinely understand. Prerequisite: PHIL-2140. Fall term annually. 

PHIL-4300 Environmental Philosophy
While concepts such as quality of life, environment, nature, global ecology, and the like figure heavily in contemporary discussions, they are seldom integrated into an environmental philosophy. The course tries to achieve this integration by understanding some of the religious, mythic-poetic, and scientific dimensions of the man-nature matrix. Some specific environmental problems are exam-
PHIL-4310 Scientific Revolutions
What is progress in science? How has our concept of progress been influenced by science? Are there significant differences between scientific and technological revolutions? These questions are explored in order to shed light on the complex dynamics of academic and industrial research. (Cross listed as STSH-4310. Students cannot obtain credit for both this course and STSH-4310.) Prerequisite: PHIL-1110 or PHIL-2130/STSH-2130. Term: offered upon availability of instructor. 4 credit hours

PHIL-4360 Philosophical Problems of Space and Time
Relevant aspects of the work of Kant, Leibniz, and Newton; Gauss, Riemann, and Poincare; Faraday, Maxwell, and Einstein. Special attention is given to the historical development of non-Euclidean geometries and the distinction between mathematical and physical geometry. Ultimately, the aim is to clarify the conceptual structure of special and general relativity by showing the problem context in which they evolved. Prerequisite: PHIL-2130 or permission of instructor. Spring term annually. 4 credit hours

PHIL-4380 Philosophy of Mathematics
Basic schools of thought about the nature of mathematical reality are described and critically analyzed. Special topics include artificial intelligence, randomness, and the work of George Cantor on transfinite numbers. Prerequisite: PHIL-1110 or PHIL-2130. Offered on availability of instructor. 4 credit hours

PHIL-4420 Computability and Logic
A team-based, project-oriented, hands-on introduction to the great concepts and discoveries in logic and computability, including Turing Machines, first-order logic, the limitations of computing machines, Godel’s incompleteness results, and so forth. A hands-on laboratory component is included. Prerequisite: PHIL-2140. Spring term annually. 4 credit hours

PHIL-4440 Knowledge, Belief, and Cognition or Theory of Knowledge
An exploration of what it means to know something, of the difference between knowing and believing, and of the relation between a knowledge claim and the evidence on which the claim is based. Students attempt to find philosophical counters to skepticism in respect to memory, knowledge, truth, knowledge of the physical world, of the self, and of other minds. Prerequisite: one course in philosophy. Spring term, alternate years. 4 credit hours

PHIL-4520 Existentialism
An examination of the works of such writers as Kierkegaard, Nietzsche, Heidegger, Sartre, and Jaspers. Attention is also given to the thought of Husserl and to the phenomenological movement. Prerequisite: one course in philosophy or permission of instructor. Term: offered upon availability of instructor. 4 credit hours

PHIL-4570 Buddhism
A study of the conditions of human suffering and human perfection according to Buddhism. The course ranges from the original teaching of Buddha to the development of Buddhism throughout Asia, including China, Tibet, and Japan. Buddhist, Chinese, and Western views of the nature of causation, freedom, existence, and human nature are compared. Prerequisite: one course in philosophy or senior standing. Spring term annually. 4 credit hours

PHIL-4720 Metaphysics
A study of how to talk about what there is. This course is concerned with the philosophical claims that have been made about existence, being, and reality, and the problem of evaluating such claims, especially in the context of the claims made by science about the same issues. Some traditional philosophical and scientific texts are discussed, but recent sources will also be important. (Cross listed as STSH-4720. Students cannot obtain credit for both this course and STSH-4720.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor. 4 credit hours

PHIL-4740 Philosophy of Law
The course examines the following questions: What is law? What is the relationship between law and morality? Is there a moral obligation not to break the law? Detailed examination is given to the concepts of liberty, justice, responsibility, and punishment. (Cross listed as STSH-4740. Students cannot obtain credit for both this course and STSH-4740.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor. 4 credit hours

PHIL-4750 Cognition and Education
We think of ourselves pre-scientifically, as “floating observers” in a theater of experience, mentally directing deliberations and willing actions. Educators approach our “aptitudes” in this way. But suppose we are primarily brains, operating as decentralized, parallel processing computational systems? How should we think of ourselves then? If we have multiple (unconscious) intelligences—not a single understanding—how should education be tailored to serve? We address such questions through cognitive science and philosophy of mind. Prerequisite: one previous course in philosophy or psychology. Offered alternate years. 4 credit hours
PHIL-4800 Comparative Cognition
What are the fundamental assumptions of cognitive science? Using a comparative approach, this course examines assumptions about the nature of mind, knowledge, self, and reality that underlie contemporary cognitive science from the perspective of traditional Buddhist mind science. Prerequisite: one course in philosophy. Alternate years.  4 credit hours

PHIL-4940 Topics in Philosophy
Experimental courses on subjects to be announced in advance. Prerequisite: permission of instructor.  1 to 4 credit hours

PHIL-4990 Capstone Experience in Philosophy
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Working either alone or in groups, students prepare written reports relating to this project, under the supervision of a faculty member. Prerequisite: permission of a supervising faculty member. Fall, spring, and summer terms annually.  3 to 6 credit hours

PHIL-6240 Logic and Artificial Intelligence
This course is about the connection between logic and artificial intelligence (AI). It may be partitioned into three general sections: 1) the straightforward application of first-order logic (FOL) in AI; 2) the broadening of FOL to enable a robot to reason in a commonsense way (nonmonotonic reasoning, induction, etc.) and to formalize a robot agent's belief and knowledge system (modal logics, etc.); and 3) using a logical approach to the Frame Problem and to building a planner. Spring term annually.  4 credit hours

PHIL-6360 Foundations of Science
This seminar explores the issues of confirmation, semantics, and interpretations of scientific theories. Positivism, realism, and the logic of scientific discovery are discussed with special attention given to foundational problems in physics and psychology. Students should have some background in philosophy of science. Term: offered upon availability of instructor.  4 credit hours

PHIL-6740 Philosophy of Mind
A study of some current issues in philosophical psychology and philosophy of psychology. The following are representative of the questions discussed: Is a person identical with his body? Is consciousness a brain process? Can computers think? Do avowals have truth-value? Is psychology possible? Occasionally additional topics are selected from such areas as phenomenology (Merleau-Ponty, Sartre) and structuralism (Levi-Strauss, Barthes). Offered on availability of instructor.  4 credit hours

PHIL-6810, PHIL-6820 Graduate Seminar I, II
This course is reserved for intensive study of some area of philosophy of mutual interest to graduate students and faculty. Offered on availability of instructor.  4 credit hours

PHIL-6940 Philosophy Studies
Independent study of a particular topic. Fall and spring terms annually.  1 to 4 credit hours

PHIL-6960 Topics in Philosophy
Fall and spring terms annually.  1 to 4 credit hours

PHIL-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master’s program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.  1 to 9 credit hours

PHIL-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  1 to 9 credit hours

PHYS Physics (SOS)

PHYS-1010 A Passion for Physics
A weekly one-hour seminar by physics department faculty members, in which they describe their scientific and research interests, at a level suitable for first year college students. This course is graded satisfactory/unsatisfactory. Fall term annually.  1 credit hour

PHYS-1050 Physical Principles of Design
Physics fundamentals for Architecture students. Mechanics with emphasis on equilibrium and statics, fluids, oscillations, and waves. Basics of thermodynamics and electromagnetic radiation. Reflection, refraction, and optics. Spring term annually.  4 credit hours

PHYS-1100 Physics I
The first semester of a two-semester sequence of interactive courses. Topics include linear and angular kinematics and dynamics, work and energy, momentum and collisions, forces and fields, gravitation, elementary electrostatics, and motion of charged particles in a magnetic field. Corequisite: MATH-1010 or equivalent or permission of instructor. Fall and spring terms annually.  4 credit hours
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit/Contact Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYS-1200</td>
<td>Physics II</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1500</td>
<td>Physical Modeling</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1860</td>
<td>Phenomena of Light and Color in the Open Air</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-1960</td>
<td>Topics in Physics</td>
<td>1</td>
</tr>
<tr>
<td>PHYS-2050</td>
<td>Science of Information Technology</td>
<td>3 or 4</td>
</tr>
<tr>
<td>PHYS-2100</td>
<td>Introduction to Methods of Theoretical Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS-2260</td>
<td>Introduction to Laboratory Electronics</td>
<td>4, 6</td>
</tr>
<tr>
<td>PHYS-2270</td>
<td>Intermediate Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-2350</td>
<td>Experimental Physics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-2370</td>
<td>Research Participation</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-2375</td>
<td>Quantum Physics</td>
<td>3 or 4</td>
</tr>
<tr>
<td>PHYS-2400</td>
<td>Fundamentals of Optics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS-2940</td>
<td>Special Projects in Physics</td>
<td>3</td>
</tr>
</tbody>
</table>
PHYS-2960 Topics in Physics
An independent investigation. Prerequisite: permission of instructor.
3 or 4 credit hours

PHYS-2990 Thesis
An independent investigation. Prerequisite: permission of instructor.
3 or 4 credit hours

PHYS-4100 Introductory Quantum Mechanics
Quantum mechanics beyond Schrodinger wave mechanics. The postulates of quantum mechanics. Second quantization, Dirac notation, Hilbert spaces, perturbation theory, and applications to simple systems. Spring term annually. 4 credit hours

PHYS-4210 Electromagnetic Theory
Field theory of electricity and magnetism with emphasis on solving boundary value problems. Dielectric and magnetic materials. Maxwell's equations and wave propagation with applications to optics. Relativistic electrodynamics. Prerequisite: MATH-2400 and PHYS-1200. Spring term annually. 4 credit hours

PHYS-4420 Thermodynamics and Statistical Mechanics
The principles and physical applications of classical thermodynamics are developed. Basic concepts in classical and quantum statistical mechanics are introduced and their relations to thermodynamics are developed. Prerequisite: PHYS-1200 (or PHYS-2510) and MATH-2400. Spring term annually. 4 credit hours

PHYS-4510 Quantum Mechanics I
Review of Schrodinger wave mechanics. Operator algebra and theory of representation. Approximation methods for stationary problems. The theory of scattering and application to atomic and nuclear scattering problems. Students cannot obtain credit for both this course and PHYS-6510. Prerequisite: PHYS-4100 or equivalent. Fall term annually. 3 credit hours

PHYS-4530 Group Theory in Quantum Mechanics
Methods for applying the principles of invariance to quantum mechanical systems. Topics include abstract group theory, theory of group representations and characters, discrete groups. Continuous groups introduced via the rotation group. Applications to atomic and nuclear physics, molecular vibrations, quantum theory of solids, with emphasis on wave functions, degeneracy of energy levels, and selection rules. Prerequisites: MATH-2100 and PHYS-4100 or permission of instructor. Spring term annually. 4 credit hours

PHYS-4620 Particles and Nuclei
This course develops current theories of the elementary structure of particles and fields and their fundamental interactions. The role of symmetries in nature is stressed, and the possible unification of the basic interactions is considered. The properties of atomic nuclei are discussed in terms of the elementary nuclear force and in terms of nuclear models such as the shell model. Prerequisite: PHYS-4100 or equivalent. Spring term annually. 4 credit hours

PHYS-4630 Lasers and Optical Systems
Optical physics and applications of lasers. Design of optical systems. Topics include: wave optics and beam propagation, Gaussian beams, resonators, optical properties of atoms and laser gain media, laser amplifiers, pulsed laser systems, applications of lasers, nonlinear optics. Three lecture hours and three laboratory hours per week. (Cross listed as ECSE-4630. Students cannot obtain credit for both this course and ECSE-4630.) Prerequisite: PHYS-2620 recommended. Fall term odd-numbered years. 4 credit hours

PHYS-4640 Optical Communications and Integrated Optics
Phenomena, materials, and devices for optical communications and computing. Topics include: guided wave and fiber optics, integrated optics, electro-optic and nonlinear optical switching, pulse and soliton propagation, sources and detectors. Three lecture hours and three laboratory hours per week. (Cross listed with ECSE-4640. Students cannot receive credit for both this course and ECSE-4640.) Prerequisite: PHYS-2620. Fall term even-numbered years. 4 credit hours

PHYS-4720 Solid-State Physics
An introduction to theoretical and experimental solid-state physics. Wave mechanics in the perfect crystal. X-rays, electrons, and phonons. Electrical properties of metals and semiconductors. Qualitative treatment of lattice defects. (Cross listed with ECSE-4720. Students cannot receive credit for both this course and ECSE-4720.) Prerequisites: PHYS-2100 and PHYS-2510 or equivalent. Fall term annually. 4 credit hours

PHYS-4750 Introduction to Surface Physics
A survey of the phenomena occurring at surfaces. Surface structure and surface electronic properties. Surface processes including adsorption, surface diffusion, crystal growth. Interaction of charged particles with surfaces. Prerequisite: PHYS-2510 or permission of instructor. Fall term annually. 4 credit hours

PHYS-4810 Computer Modeling in Physics
A survey course in the basic techniques of computational physics, emphasizing studies of physical systems by numerical experimentation. The systems to be studied include examples from plasma physics, nuclear physics, condensed matter physics, high energy physics, and astrophysics. Prerequisites: CSCI-1100, PHYS-1100, and PHYS-1200 or permission of instructor. Spring term odd-numbered years. 4 credit hours

PHYS-4960 Topics in Physics
4 credit hours

PHYS-6110 Methods in Theoretical Physics
Vector calculus and partial differential equations, especially with applications to electrodynamics. Separation of variables and second-order differential equations. Sturm-Liouville theory with applications to special functions.
Complex analysis and conformal mapping. Green functions and boundary value problems. Fall term annually.  

**PHYS-6310 Advanced Mechanics**
Variation principle formulation; applications to two-body central force problems and to rigid body motion; small oscillations and normal modes; Hamilton's equations of motion; Hamilton-Jacobi theory. Prerequisite: PHYS-2330 or equivalent. Fall term annually.  

**PHYS-6410 Electrodynamics**

**PHYS-6510 Quantum Mechanics I**
Review of Schrodinger wave mechanics. Operator algebra and theory of representation. Approximation methods for stationary problems. The theory of scattering and application to atomic and nuclear scattering problems. Students cannot obtain credit for both this course and PHYS-4510. Prerequisite: PHYS-4100 or equivalent. Fall term annually.  

**PHYS-6520 Quantum Mechanics II**

**PHYS-6530 Quantum Mechanics III**

**PHYS-6590 Statistical Mechanics**
The study of classical and quantum statistical mechanics. The relationship to thermodynamics and applications to gases and solids. Prerequisite: PHYS-6510. Spring term annually.  

**PHYS-6620 Nuclear and Particle Physics I**
An introduction to the physical concepts and methods of modern nuclear and elementary particle physics, for specialists and nonspecialists. Nonrelativistic scattering theory, resonance production, group symmetries and conservation laws, quark-model of hadron structure, and simple Feynman diagrams. Prerequisite: PHYS-6520. On availability of instructor.  

**PHYS-6630 Nuclear and Particle Physics II**

**PHYS-6710 Theory of Solids I**

**PHYS-6720 Theory of Solids II**
More detailed application of solid-state theory to electrical, magnetic, and optical properties of matter. Consideration of particular materials; semiconductors, ferries, ferroelectrics, and superconductors. Prerequisite: PHYS-6710. On availability of instructor.  

**PHYS-6730 Advanced Solid-State Physics**

**PHYS-6810 Nonlinear and Quantum Optics**

**PHYS-6900 Seminar**
Selected topics. Credit hours to be arranged.  

**PHYS-6940 Readings in Physics**
Supervised reading and study in various fields of physics.  

**PHYS-6960 Topics in Physics**
Variable credit hours.  

**PHYS-6970 Professional Project**
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements.
With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

PHYS-6980 Master’s Project
Active participation in a Master’s-level project under the supervision of a faculty adviser, leading to a master’s Project report. Grades of IP are assigned until the master’s project has been approved by the faculty adviser. If recommended by the adviser, the master’s project may be accepted by the Office of Graduate Education to be archived in the Library. Grades will then be listed as S. 1 to 9 credit hours

PHYS-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. 1 to 9 credit hours

PHYS-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S. Variable credit hours

PSYC Psychology (HSSS)

PSYC-1200 General Psychology
An introduction to psychology. Topics covered vary with instructor but may include physiological bases of behavior, sensation, perception, learning, memory, child and adult development, motivation, personality, psychological disorders, social behavior. Introduction to basic methods of psychological research is a course requirement that can be met in several ways (described during the first class meeting). There is a significant experiential component that varies with the instructor but will include interactive computer stimulations, class demonstrations, group projects. Fall, spring, and summer terms annually. 4 credit hours

PSYC-2210 Introduction to Human Computer Interaction
An introduction to the current theories, methods, and issues in human-computer interaction. Theory and research along with practical application are discussed within the context of organizational impact. The course provides the knowledge of HCI systems and research used for the implementation of safe, quick, and useable technologies. (Cross listed as ITEC-2210. Students cannot obtain credit for both this course and ITEC-2210.) Fall term annually. 4 credit hours

PSYC-2220 Human Factors in Design
This course provides a broad introduction to the theories and principles of human performance, man-machine interfaces, and systems designs. It also emphasizes the applications of these theories and principles to the design of controls, work space, data entry devices, training systems, and the human-computer interface. Prerequisite: PSYC-1200 or permission of instructor. Annually. 4 credit hours

PSYC-2310 Experimental Methods and Statistics
This course provides an introduction to basic methods of psychological research and the use of statistics to interpret psychological data. Students participate in several experiments and prepare written reports. Topics include experimental design, data collection and analysis, and communication of results. Prerequisite: PSYC-1200. Spring term annually. 4 credit hours

PSYC-2600 Moral Development
An analysis of psychological research on how our commonsense moral beliefs develop from early childhood through old age, and their application to daily problems. A major focus is on the conflict between themes of justice or individual rights and caring compassion and its relation to gender differences (the Kohlberg/Gilligan debate). (Cross listed as PHIL-2600. Students cannot obtain credit for both this course and PHIL-2600.) Annually. 4 credit hours

PSYC-2730 Social Psychology
This is a survey course covering theories, methods, and empirical research on personal and situational factors influencing social behavior. Topics covered include social perception, the construction of social reality, decision making, group influences on behavior, and attitudes. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC 2800 Introduction to Sports Psychology
An introduction to psychology as applied to sport, the topics covered include history of sport behavior, principles of learning and their application, anxiety and arousal, motivation, leadership, cohesion, audience effects, aggression, personality assessment, female athletes, youth in sport, coach behavior, and physical activity for all. Prerequisite: General Psychology 1200. Fall term annually. 4 credit hours
PSYC-4110 Motivation and Performance
This course encompasses a broad spectrum of theories concerned with the biological, psychological, and social components of motivation. Throughout the course, students relate theoretical issues to both recent research evidence and potential practical applications to enhance performance. Group projects, focus group discussions, and interactive guest speakers are used to establish links between theory and performance. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4160 Human Factors Seminar
A comprehensive, project-oriented survey of special topics in human factors. Applied, experimental, and/or field research will be required. Prerequisite: PSYC-2220 or permission of instructor. Offered on sufficient demand. 4 credit hours

PSYC-4180 Selected Topics in Engineering Psychology
An interactive seminar in human factors involving discussion of recent research on visual displays, multiple resources, mental work load, skill training, and reaction time. Corequisite: PSYC-2220 or graduate status. Spring term annually. 4 credit hours

PSYC-4190 Program Evaluation
Methods and procedures of evaluating program effectiveness in public and private organizations are critically evaluated. The integration of organizational principles and quantitative techniques is stressed. Prerequisite: PSYC-1200 and one statistics course. Annually. 4 credit hours

PSYC-4200 Industrial and Organizational Psychology
A broad introduction to the field of Industrial and Organizational Psychology. Topics covered include personnel selection, job analysis, training, performance appraisal, work-related attitudes, employee motivation, leadership, decision making, and organizational theory. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4260 Psychological Tests and Measurements
Methods, techniques, and instruments for measuring individual differences are surveyed. Topics include representative methods of test construction, a critical analysis of representative tests, criteria for evaluating and selecting tests, and the value and limitations of tests. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4280 Human-Computer Interaction
Covers current topics in the field of human-computer interaction design including research in interactional hardware and software, matching models, tasks, design, and organizational impact. Class discussion focuses mainly on theory and practice from the perspectives of cognitive science and cognitive engineering. Prerequisites: PSYC-1200 and PSYC-2220 or permission of instructor. Annually. 4 credit hours

PSYC-4320 Psychobiology
The neural and hormonal systems are studied in an evolutionary perspective with particular emphasis on the relation between physiological systems and human performance. Group projects, computer-simulated experiments, and film-clip-based discussions provide a multifaceted interactive component. Prerequisite: PSYC-1200. Spring term annually. 4 credit hours

PSYC-4340 Human Sexuality
This course provides biological, cultural, historical, and psychological perspectives of sexuality. Basic information on human development and reproductive physiology is provided. In addition, current topics such as marriage, alternate lifestyles, contraception, and pornography are discussed. Small group focus discussions, media-based discussions, and interactive guest speakers are used to link course material to responsible sexuality and understanding of diversity. Prerequisite: PSYC-1200. Spring term annually. 4 credit hours

PSYC-4370 Cognitive Psychology
The focus of this course is on the flow of information from sensory input to retrieval from long-term memory. Within this framework, topics such as mnemonics, pattern recognition, attention, computer simulation, reasoning, and the relationship between culture and thought are discussed. Prerequisite: PSYC-1200. Fall term annually. 4 credit hours

PSYC-4400 Personality
Modern theories of personality are presented and compared. Using these theories, students analyze the processes by which people cope with intrapsychic, interpersonal, and institutional demands. Evidence on adaptive processes from clinical, field, and laboratory studies is evaluated. Prerequisite: PSYC-1200. Offered on availability of instructor. 4 credit hours

PSYC 4410 Sensation and Perception
What are the processes that allow us to detect information about our surroundings, recognize people and objects, and perceive depth and motion? This course will focus on the physiological and neural mechanisms underlying sensation (sight, hearing, and touch), the qualitative aspects of human perceptual experience, and how perception and action are interconnected. Color perception, object recognition, space and motion perception, and perception and action are all examined. Prerequisite: PSYC-1200 General Psychology. Annually. 4 credit hours

PSYC 4420 Perception in Action
This course will focus on the role of perception in the performance of both routine and skilled goal-directed activities, such as walking along a crowded sidewalk, playing sports, and driving automobiles. Content will be drawn from current empirical, theoretical, and computational research on such topics as perceiving direction of self-
motion, intercepting moving objects, catching and hitting balls, and avoiding collisions with obstacles. Prerequisite: PSYC-4410 Sensation and Perception. Spring term annually. 4 credit hours

PSYC-4430 Foundations of Instruction and Learning in Secondary School Education II
A continuation of ISCI-4400. Students spend at least four hours per week working with teachers in the Troy School District and four hours each week in a problem-solving experience at Rensselaer. (Cross listed as NSST-4410. Students cannot obtain credit for both this course and NSST-4410.) Prerequisite: NSST-4400. Spring term annually. 6 credit hours

PSYC-4450 Learning
The first half of this course is devoted to presentation of traditional theories of learning. Classical and operant conditioning and single-subject methodology are studied in depth. During the second half of the course, students apply their knowledge of operant conditioning principles in the context of a group-based field study. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4470 Drugs, Society, and Behavior
This course is an exploration of the social and psychological effects of extensive use of pharmacological agents that are salient to daily behavior. There is an emphasis on the effects of addictive drugs such as alcohol, heroin, and cocaine. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC 4510 Cognitive Modeling
Cognitive modeling refers to the study of human cognition through computational modeling of cognitive processes. The purpose of this course is to teach the skills involved in developing cognitive models. We will review the results in cognitive psychology including those from perception, memory, problem solving, and learning, and develop computer programs to model those results. Prerequisite: CSCI-1100 and CSCI-1200 and PSYC-1200. Recommended: PSYC-4370 Annually. 4 credit hours

PSYC-4600 Cognition and the Brain
Perception and thought are considered in terms of processes represented in the brain. The localization and lateralization of function are examined, drawing upon research on the behavioral effects of brain damage as well as brain-imaging studies and other approaches. Examples of topics include object recognition, memory, language, emotion, spatial ability, and motor processes. Prerequisite: PSYC-1200. Fall term annually. 4 credit hours

PSYC-4630 AIDS: Paradise Lost
AIDS, with its combination of sex, death, and celebrities, holds a strong fascination for our society. The AIDS story is a complex one, shaped by a number of forces. While the primary focus is on the biology of the HIV virus and its interface with the immune system, we do not neglect how social, technical, administrative, political, legal, and economic factors mold the AIDS story. (Cross listed as BIOL-4430. Students cannot obtain credit for both this course and BIOL-4430.) Prerequisite: BIOL-2120. Spring term annually. 4 credit hours

PSYC-4720 Abnormal Psychology
The definition, history, major schools of thought, and models of the normal and abnormal personality are presented. Disorders are examined within the framework of D.S.M. and competing schools of thought. The description, etiology, treatment, including pharmacological, and prevention of each of the disorders are considered. Illustrative cases are presented. Students write a paper on a topic, approved by the instructor, that focuses upon the impact of public policies on psychopathology. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC 4740 Psychology and The Law
Since the 1950's, social science researchers have turned their attention to the courtroom, in order to test theories of human behavior in a real world application. Are the basic assumptions underlying the practice of law in this country valid, given what psychologists know about the fundamentals of human behavior? This course will provide students with instruction regarding how the study of psychology can contribute to a better understanding of the legal system. Prerequisite: PSYC-1200. Fall term annually. 4 credit hours

PSYC 4750 Forensic Psychology
A practical introduction to the field of forensic psychology, a domain within psychology concerned with the production and application of psychological knowledge to the civil and criminal justice systems. In this course, we explore the many ways in which psychological principles play an increasingly important role in influencing various processes and outcomes associated with the field of law. Prerequisite: PSYC-4740. Spring term annually. 4 credit hours

PSYC 4770 Psychopharmacology and Behavioral Toxicology
This course is a detailed examination of the neuroscience and psychology inherent to the development of pharmacological agents for treating psychopathology. There is also an exploration of chemicals that are toxic to the brain as manifest by induction of psychopathology. Prerequisite: PSYC-1200. Annually. 4 credit hours

PSYC-4940 Readings in Psychology
An individually arranged independent study course under the supervision of a member of the Psychology Department. The topic is selected by consultation between student and faculty member. Prerequisite: PSYC-1200 and/or permission of supervising faculty member. 1 to 4 credit hours
PSYC-4960 Topics in Psychology
An advanced course concerned with selected topics in psychology. Prerequisite: PSYC-1200 or permission of instructor.  1 to 4 credit hours

PSYC-4990 Undergraduate Thesis
Students conduct original scholarly projects: original research, theoretical or analytical reviews of the literature, or computer simulations. Working either alone or in groups, students prepare written reports related to this project, under the supervision of a faculty member. Prerequisite: permission of a supervising faculty member. Fall, spring, and summer terms annually.  3 to 6 credit hours

PSYC-6170 Advanced Human Factors
This seminar covers some of the basic principles and findings in human performance and human factors in design. Examples of the selected topics include psychophysics, human capabilities and limitations, mental work load, motor performance, feedback and knowledge of results, displays and controls, anthropometry, task analysis, and computer-user communications. Prerequisites: graduate status and PSYC-2220 or permission of instructor. Offered on availability of instructor.  4 credit hours

PSYC-6180 Engineering Psychology
This interactive seminar deals with some of the basic principles and findings in engineering psychology. The course emphasizes the discussion of recent research on visual displays, multiple resources, mental work load, skill training, and reaction time, as it applies to human factors issues. Prerequisite: permission of instructor. Spring term annually.  4 credit hours

PSYC-6200 Cognition
Current issues and methodologies in cognitive psychology are discussed. Topics include sensory processes, signal detection theory, semantic memory, selective attention, automatic processes, reading behavior, and text comprehension. These topics are covered in an in-depth manner that includes critical evaluation and synthesis of major issues. Graduate students only. Fall term annually.  4 credit hours

PSYC-6240 Cognitive-Systems Engineering
This is a project-based seminar. Course work covers the design and development process for applying a cognitive science to system design. Topics include design systems, mental models, design evaluation, analytical techniques, expert systems, knowledge elicitation, human-computer dialog, and automated design. Annually.  4 credit hours

PSYC-6320 Seminar in Psychopharmacology
This course deals with the recent literature on selected topics in psychopharmacology and neuroscience. Prerequisite: PSYC-4770. Annually.  4 credit hours

PSYC-6340 Seminar in Industrial Psychology
This class integrates research and practice in industrial psychology. In-depth coverage of current issues relevant to job analysis, personnel selection, placement, performance evaluation, and compensation is provided. The implications of legislation enacted to provide equal employment opportunity on personnel issues is also examined. Prerequisite: graduate status or permission of instructor. Annually.  4 credit hours

PSYC-6350 Seminar in Organizational Psychology
A seminar for reading and discussing methods and substance data in organizational psychology (micro-level analysis) and some organizational theory (macro-level analysis). Current theories in the areas of motivation, leadership, expectancies, learning, equity, and goal setting are presented and discussed. This course requires the completion of a research proposal in the area of organizational psychology for the purpose of introducing students to the methods used for testing theory and applying theory to organizational settings. Prerequisite: graduate status or permission of instructor. Spring term annually.  4 credit hours

PSYC-6370 Seminar in Organizational Conflict
A broad introduction to negotiation, bargaining, third-party intervention, and conflict within organizational settings. Theoretical perspectives, factors contributing to conflict, and techniques for resolving conflict are discussed. Prerequisite: graduate status or permission of instructor. Annually.  4 credit hours

PSYC-6420 Seminar in Organizational Development
The first half of the course is a comprehensive survey of the field. The second half is a project in an industrial, governmental, educational, recreational, or health care organization. Prerequisite: graduate status or permission of instructor. Spring term annually.  4 credit hours

PSYC-6540 Visual and Auditory Psychophysics and Perception
This course is an advanced survey of these fields derived from recent laboratory and clinical laboratory research. It covers both sensory and perceptual phenomena. To some extent, specific topics will be governed by class interests, but will include the neurobiology of the auditory and visual systems, their psychophysics and systems, auditory and visual prosthetics. The course is directed to provide a sound foundation for students of cognitive science. Students are expected to select and execute a research project. Prerequisite: PSYC-4410 or permission of instructor. Offered on availability of instructor.  4 credit hours

PSYC-6570 Advanced Behavioral Statistics
An accelerated course covering important behavioral statistical concepts including probability, sampling distributions, hypothesis testing, ANOVA, and multiple regression. Course requires usage of statistical software package
and is taught using the general linear model framework. Prerequisite: graduate status and one course in undergraduate statistics. Fall term annually.  

PSYC-6690 Seminar in Research Design  
An in-depth study of quasi-experimental and experimental design of behavioral research. Topics include test construction and development, factor analysis, meta-analysis, repeated measures, and MANOVA. Prerequisite: PSYC-6570 or permission of instructor. Spring term annually.  

4 credit hours

PSYC-6940 Readings in Psychology  
An individually arranged independent study course under the supervision of a member of the Psychology Department. The topic is selected by consultation between student and faculty member. Prerequisite: graduate status and permission of supervising faculty member.  

1 to 4 credit hours

PSYC-6960 Topics in Psychology  
An advanced course concerned with selected topics in psychology. Prerequisite: permission of instructor.  

1 to 4 credit hours

PSYC-6970 Professional Project  
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.  

1 to 9 credit hours

PSYC-6990 Master's Thesis  
Active participation in research, under the supervision of a faculty adviser, leading to a master's thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  

1 to 9 credit hours

STSH Science and Technology Studies—Humanities Credit (HSSH)  
(For Science and Technology Studies-Social Sciences Credit, see STSS.)

STSH-1110 Science, Technology, and Society  
An introduction to the social, historical, and ethical influences on modern science and technology. Cases include development of the atomic bomb, mechanization of the workplace, Apollo space program, and others. Readings are drawn from history, fiction, and social sciences; films and documentary videos highlight questions about the application of scientific knowledge to human affairs. The class is designed to give students freedom to develop and express their own ideas. (Cross listed as STSS-1110. Students cannot obtain credit for both this course and STSS-1110.) This course can be used to satisfy either humanities or social sciences distribution requirements. Fall and spring terms annually.  

4 credit hours

STSH-2130 Introduction to Philosophy of Science  
How does science stimulate philosophical thinking and how has philosophy influenced science? This broad range of interaction is studied with special attention given to the concepts of theory, observation, and scientific method. Special attention is given to issues basic to psychology, in particular, reductionism, behaviorism, functionalism, and cognitivism. (Cross listed as PHIL-2130. Students cannot obtain credit for both this course and PHIL-2130.) Fall term annually.  

4 credit hours

STSH-2410 Century of the Gene  
This course details the scientific and social history of genetics, from Darwin and Mendel to the Human Genome Project. Special focus areas include: plant and animal breeding in the early twentieth century; eugenics movements in the U.S. and elsewhere; bacterial and fruit fly genetics; the development of molecular biology; the invention of recombinant-DNA technologies; the emergence of the biotechnology industry; the sociobiology controversies; genetics and evolutionary theory; and the Human Genome Project and contemporary genomics. Fall and spring annually.  

4 credit hours

STSH-2500 Bioethics  
This course involves a philosophical analysis of some of the basic moral issues raised by recent and anticipated developments in the areas of biology and medicine. The general question “What are moral problems, and how does one resolve them?” is examined in the context of concrete cases involving issues such as abortion, euthanasia, organ transplants, experimentation on human patients, cloning,
STSH-2670 History of 19th Century Europe
A treatment of the major events and issues in European history from the French Revolution to the eve of the First World War. The main focus is on the interplay among politics, economics, technology, and society as Europe changed from a largely agrarian to a predominantly industrial society. Annually.

STSH-2720 Masculine/Feminine
What are our conceptions of being a woman or a man, a daughter or a son, a wife or a husband, a mother or a father? This course attempts to answer this question from a variety of perspectives, including history, biology, social psychology, anthropology, and especially philosophy. Emphasis is placed on the potential for sexual liberation in being friends or lovers, in a marriage or a family, as well as in a career. Offered on availability of instructor.

STSH-2940 Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic.

STSH-2960 Topics in Science and Technology Studies

STSH-4170 Ethical Issues in Computing
This course examines the ethical issues that arise as a result of increasing use of (and dependence on) computers and the responsibilities of computer professionals with regard to these issues. The course stresses the ways computers challenge traditional ethical and philosophical concepts and raise old issues in a new way. Topics include codes of conduct for computer professionals, property rights in computer software, privacy, cracking, liability, and responsibility in computing. Prerequisite: STSH-1110/STSS-1110, STSS-2400, or permission of instructor. Alternate years.

STSH-4230 Engineering Ethics
This course explores the ethical issues that engineers encounter in their professional practice. It also examines social values and law and policy issues that shape engineering and technological decision making. Using case studies, professional codes of conduct, and scholarly literature, the course examines the responsibilities of engineers in relation to their employers, clients, co-professionals, and their responsibility for public safety and welfare. Topics include the history of engineering, professionalism vs. the demands of business, engineering vs. management decision making, whistle-blowing, proprietary rights and trade secrecy, and conflicts of interest. Prerequisite: STSH-1110/STSS-1110, STSS-2400, or permission of instructor. Alternate years.

STSH-4300 Environmental Philosophy
While concepts such as quality of life, environment, nature, global ecology, and the like figure heavily in contemporary discussions, they are seldom integrated into an environmental philosophy. The course tries to achieve this integration by understanding some of the religious, mythic-poetic, and scientific dimensions of the human-nature matrix. Some specific environmental problems are examined to illustrate the system of values implied by various solutions. (Cross listed as PHIL-4300. Students cannot obtain credit for both this course and PHIL-4300.) Prerequisite: junior or senior standing or permission of instructor. Offered on availability of instructor.

STSH-4310 Scientific Revolutions
What is progress in science? How has our concept of progress been influenced by science? Are there significant differences between scientific and technological revolutions? These questions are explored in order to shed light on the complex dynamics of academic and industrial research. (Cross listed as PHIL-4310. Students cannot obtain credit for both this course and PHIL-4310.) Prerequisite: PHIL-1110 or PHIL-2130/STSH-2130. Fall term alternate years.

STSH-4420 - Biofutures
This course examines the forefronts of genetics and biotechnology, and their social and ethical implications, through multiple lenses: writings of scientists and science fiction writers, and historians, philosophers, and anthropologists of the life sciences. Topics may include: genetic testing and gene therapy; sports medicine; cosmetic psychopharmacology; patents and intellectual property; transgenic organisms; organ transplants and artificial organs; stem cell research; genetic enhancement; artificial life; cloning; cloning; and other related topics. Prerequisites: any STS course, or permission of the instructor. Spring term annually.

STSH-4570 Indian Politics and Culture
This course explores the roots and consequences of change in India, examining recent economic reforms, technological development, environmental crisis, increasing religious fundamentalism, poverty, population growth, and trends in literature, film, and art. The objective of the course is to provide students with a nuanced understanding of how social, cultural, and political-economic factors interact, complicating efforts to build sustainable modes of governance in the Third World. Fall term alternate years.

STSH-4580 Modern Latin America
A general introduction to Latin American culture: history from the colonial era to the present; Afro-American, Native American, and Euro-Latin cultures as portrayed in literature and ethnography; and current issues, such as race and racism and development and the local populations. (Cross listed as STSS-4580. Students cannot obtain cred-
it for both this course and STSS-4580.) Prerequisite: one H&SS course or permission of instructor. Offered on availability of instructor. 4 credit hours

STSH-4720 Metaphysics
A study of how to talk about what there is. This course is concerned with the philosophical claims that have been made about existence, being, and reality, and the problem of evaluating such claims, especially in the context of the claims made by science about the same issues. Some traditional philosophical and scientific texts are discussed, but recent sources will also be important. (Cross listed as PHIL-4720. Students cannot obtain credit for both this course and PHIL-4720.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor. 4 credit hours

STSH-4740 Philosophy of Law
The course examines the following questions: What is law? What is the relationship between law and morality? Is there a moral obligation not to break the law? Detailed examination is given to the concepts of liberty, justice, responsibility, and punishment. (Cross listed as PHIL-4740. Students cannot obtain credit for both this course and PHIL-4740.) Prerequisite: one philosophy or STS course or permission of instructor. Offered on availability of instructor. 4 credit hours

STSH-4750 Troy, A 19th-Century Industrial City
A study, taking advantage of the university's locale, about industrialization as one important component in the development of American culture. Topics such as water for transportation and energy sources, architectural and engineering developments in conjunction with industrial growth, and social and political problems arising out of 19th-century industrialization are considered. Each student must keep a journal and is required to undertake a project and report findings in class. Classes are complemented by frequent, usually short, field trips to appropriate sites that are agreed upon by instructor and students. Prerequisite: one college-level course in American history or permission of instructor. Fall term annually. 4 credit hours

STSH-4760 American Material Culture Down to the 20th Century (American Architecture and Artifacts, 1700-1850)
An attempt to understand the elements that have entered into the formation of the American culture, and therefore an attempt to understand the American culture itself. This is accomplished by a visual study of the architecture and artifacts of America during its formative period. Each student must keep a journal and is required to undertake a research project and report the findings to the class. Classes are complemented by frequent, usually short, field trips at times agreed upon by instructor and students to appropriate sites. Prerequisite: a college-level course in American history or permission of instructor. Spring term alternate years. 4 credit hours

STSH-4780 Medieval Architecture and Art
An attempt to grasp the meaning of the Middle Ages as a time of spiritual insight and experience sandwiched between the Classical and Renaissance ages of reason. This is accomplished by a visual study of the architecture, sculpture, and painting of the period. The medieval culture offers insights into the contemporary experience. Each student must keep a journal and is required to undertake a research project and report the findings to the class. Classes are complemented by frequent, usually short, field trips at times agreed upon by instructor and students to appropriate sites. Prerequisite: a college-level course in American history or permission of instructor. Spring term alternate years. 4 credit hours

STSH-4800 Public Service/Professional Careers Internships
This course offers an insight into the public policy process from the vantage point of a part-time internship in the public or private sector as well as an opportunity to explore a career option before actually embarking upon it. The following is a partial list of the large number of possible internships: airport planning, architecture, banking, biological research, clinical psychology, computer science, consumer protection, corporate management, engineering, environmental planning, geology, local government, materials and mechanical engineering, noise pollution abatement, personnel management review, premedical, public finance and taxation, public health management, public relations, social work, state legislature, stock market, transportation planning, and urban planning. (Cross listed as STSS-4800. Students cannot obtain credit for both this course and STSS-4800.) Prerequisites: STSH-1110/STSS-1110; IHSS-1960; or permission of instructor. Fall and spring terms annually. 4 credit hours

STSH-4900 Science, Technology, and Society Seminar: Selected Topics
In seminar style, all participants have the opportunity to choose materials/topics and lead discussions. General topic varies each time the seminar is offered. We emphasize our own relationships in the community of science and technology studies. Restricted to S&S majors. Spring term annually. 4 credit hours

STSH-4920 Topics in Science, Technology, and Society
Selected topics in science and society to meet the needs of science and society majors. Previous courses offered include Technology, Minorities, and Women; Birth and Death; Fraud and Misconduct in Science; Utopian Thought; Engineering and Society: The Art of Design;
Nature/Nurture Controversies; and Warfare: Social Dimensions. Prerequisite: any 2000-level STS course or consent of instructor. 4 credit hours

STSH-4940 Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic. 4 credit hours

STSH-4960 Topics in Science and Technology Studies 4 credit hours

STSH-4980 Senior Project
Ordinarily consists of independent research, supervised by a faculty member, culminating in a written thesis. A creative endeavor such as a videotape or computer program may be substituted with departmental permission. Restricted to S&S majors with senior standing. Fall, spring, and summer terms annually. 4 credit hours per term (maximum of 6 total)

STSH-6020 Values and Policy
This course examines the ways in which policy decisions are influenced by values and the ways in which values and value issues are affected by policy decisions. Normative concepts and theories including theories of social justice, the role of individual autonomy, democratic process, and paternalism are examined for their implications for social policies. Case studies of particular policy controversies are used. Spring term annually. 3 credit hours

STSH-6030 Nature of Inquiry
This course focuses on the role of the inquirer in inquiry, the relationship between language and inquiry, and the organizational and institutional contexts of inquiry. The emphasis in this course is on the methods of inquiry used in the humanities in relationship to STS problems. Required of STS doctoral students, other students by permission. Alternate years. 3 credit hours

STSH-6040 Cultures of Inquiry
An historical overview of the contrast between universal and local theories of knowledge. Readings begin with classic philosophy (Descartes, Hume, Kant, etc.), and the break from these universalist frameworks through modernist theories for cross-cultural comparison of knowledge systems (indigenous, national, folk, etc.). These in turn are critiqued through postmodern cultural theory, including popular culture studies, cyberculture, and postcolonial studies. Annually. 3 Credit Hours

STSH-6300 Advanced Environmental Philosophy
Conducted in conjunction with STSH-4300, with additional graduate-level readings and assignments. Offered on the availability of instructor. 3 credit hours

STSH-6940 Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic. 3 credit hours

STSH-6960 Topics in Science and Technology Studies 3 credit hours

STSH-6970 Professional Project
Active participation in a semester-long project, under the supervision of a faculty adviser. A Professional Project often serves as a culminating experience for a Professional Master's program but, with departmental or school approval, can be used to fulfill other program requirements. With approval, students may register for more than one Professional Project. Professional Projects must result in documentation established by each department or school, but are not submitted to the Graduate School and are not archived in the library. Grades of A, B, C, or F are assigned by the faculty adviser at the end of the semester. If not completed on time, a formal Incomplete grade may be assigned by the faculty adviser, listing the work remaining to be completed and the time limit for completing this work.

STSS Science and Technology Studies—Social Sciences Credit (HSSS)

(For Science and Technology Studies-Humanities Credit, see STSH.)

STSS-1110 Science, Technology, and Society
An introduction to the social, historical, and ethical influences on modern science and technology. Cases include development of the atomic bomb, mechanization of the workplace, Apollo space program, and others. Readings are drawn from history, fiction, and social sciences; films and documentary videos highlight questions about the application of scientific knowledge to human affairs. The class is designed to give students freedom to develop and express their own ideas. (Cross listed as STSH-1110. Students cannot obtain credit for both this course and STSH-1110.) This course can be used to satisfy either humanities or social sciences distribution requirements. Fall and spring terms annually. 4 credit hours

STSS-1210 Sociology
A study of the principles and concepts of sociology and their application to the study of society and self. Students are introduced to the scope, materials, and methods of sociology. The issues and problems to be studied come from basic social institutions such as the family, science, and religion. Other topics may include love, crime, political economy, power, population growth, social class, and minority and ethnic relations. Fall and spring terms annually. 4 credit hours
STSS-1310 Principles and Practices of American Government
An analytical survey of the essential features of American government within the national setting of environmental and historical factors. Among the topics included are the foundations and characteristics of American constitutionalism; the principles of federalism and the boundaries of federal, state, and local governments; the structure and dynamics of political parties; the activities and interrelations of the legislative and executive branches on all levels of American government; the judicial process and judicial review. Offered on availability of instructor. 4 credit hours

STSS-1330 International Relations
The world today faces enormous problems: the bloody horrors of war, the unconscionable and widening economic gap between rich and poor countries, and the looming threat of catastrophic environmental degradation. This course examines the causes and consequences of these problems, wonders what a world beyond greed and hate would look like, and considers what it will take to build a better world. Toward these ends, several themes are explored, including the nature of the international system, contemporary challenges to the state system, and alternatives to hunger, exploitation, and international violence. Annually. 4 credit hours

STSS-1510 Cultural Anthropology
An introduction to human societies and cultures in comparative perspective, from tribal societies to complex societies such as the United States. Emphasis on ethnographic descriptions of other cultures such as on the interpretation of cultural symbolism and on topical issues such as medical anthropology. Annually. 4 credit hours

STSS-1960 Topics in Science and Technology
4 credit hours

STSS-2100 Medicine and Society
The purpose is to explore the contributions of anthropology, sociology, and history to health and illness. By the end of the course, students will have an overall picture of health fields, problems faced by patients and caregivers, medicine and health in non-Western societies, and the social shaping of disease and therapeutic choices. This course introduces the Medicine and Society Minor Concentration. Annually. 4 credit hours

STSS-2200 Engineering, Design, and Society
What is engineering? How should engineering fit into society? What is engineering design? What role should engineering designers play in society? How do the social and technical aspects of design relate to each other? This course will explore answers to these questions through a variety of perspectives and case studies. Annually. 4 credit hours

STSS-2300 Environment and Society
The course’s main theme is ecological sustainability: what it is, how it might be achieved, how it can be maintained. The theory and practice of sustainability is explored in three parts: through an examination of the concepts, actors, and processes of society-environment interactions; through an analysis of environmental philosophies and models for action; and by addressing the problems and prospects for building sustainable societies. This course prepares students for advanced environmental humanities and social sciences courses. Prerequisite: STSH-1110/STSS-1110 or permission of instructor. Annually. 4 credit hours

STSS-2400 Law, Values, Public Policy: Perspectives on Science and Technology
This course examines the interconnections between values and law, seeking to understand how these affect and are affected by science and technology by examining such topics as computers and privacy; medical malpractice, abortion, and other legal conflicts surrounding new reproductive technologies, problems of expert witnesses, sexual harassment, patent infringement, auto safety litigation, and siting of hazardous facilities, among others. Annually. 4 credit hours

STSS-2500 Historical and Cultural Perspectives on Science and Technology
An introduction to historical and comparative aspects of science and technology, with special attention paid to issues of culture and power. The course covers differences among Western cultures and between Western and non-Western cultures. Offered on availability of instructor. 4 credit hours

STSS-2550 Information, Society and Culture
This course examines the social and cultural effects of information technology. One section explores how cultural, economic, and ethical factors influence the design of information systems. A second section explores how access to information and communication can impact health, education, family structure, labor force participation and income distribution. The final section of the course explores shifts in the way societies are governed and in the way citizens participate in movements for social change. Annually. 4 credit hours

STSS-2560 Human Evolution
The systematic study of human origins has excited scientific and popular imaginations since Darwin. We consider two overlapping frameworks, sociobiology and paleoanthropology, for explaining the evolution of behavior. Topics include “selfish gene” theories of biological altruism, adaptation, and organism-environment interaction. We also develop critical perspectives on the exchange of ideas between science and society in determining the nature of human nature. Offered on availability of instructor. 4 credit hours
STSS-2630 Foundations of American History
An examination of the formative period of the nation's development, to 1877. Coverage includes the alteration of an Anglo-European culture to an American one; the causes for the colonial break with Britain; the problems of independence; the appearance and impact of American nationalism; Westward expansion and industrialization; and the causes and effects of the sectional clash. Annually. 4 credit hours

STSS-2640 History of the United States Since 1877
A survey of American history from the end of Reconstruction to the present. The course examines such major themes as industrialization, the rise of the city, and the impact of new technologies; it surveys the progressive movement, Theodore Roosevelt, Wilson, and the United States in World War I; and it concludes by treating the economic depression of the 1930s, the New Deal of Franklin D. Roosevelt, the U.S. in World War II, and political and social developments from Kennedy to Carter. Annually. 4 credit hours

STSS-2680 History of Contemporary Europe
A topical study of European history from 1914 to the present. This course deals with World War I, Bolshevism in the Soviet Union, the Red scare and the rise of fascism, economics during the Depression and the work of Keynes, World War II, the rise of the technological society, the Cold War, and demographic and cultural patterns. Annually. 4 credit hours

STSS-2740 World War II
A topical survey of the origins, course of events, and results of World War II (1935-1945). The course covers the international economic crisis of the 1930s; the rise of totalitarianism in Europe; the wars in Ethiopia, China, and Spain; German military expansion; the war on the Eastern front and in the Pacific; the Mediterranean campaigns; naval operations; the Grand Alliance of the Allied powers; and the spread of communism in Europe and Asia. Annually. 4 credit hours

STSS-2940 Readings in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology
With an individual faculty member on an agreed-upon topic. 4 credit hours

STSS-2960 Topics in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology 4 credit hours

STSS-4110 Social Effects of Science and Technology
Effects of science and technology on social life are examined in specific contexts, such as agriculture, mining, factory and office work, and the home. Other topics may include the impact of electronic technologies, the changing role of science and scientists, and issues of social control. Goals are to present information about the effects of science and technology and to introduce social science concepts and methods useful in thinking about those effects. Prerequisite: STSH-1110/STSS-1110 or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4130 Decision Making
Recent research suggests that how people do make decisions deviates from how people rationally should make decisions. Both topics are the focal concern of the course, which surveys the influence of mental heuristics and biases, social context, and affect on judgment and choice. The material for examining individual and group decisions is drawn from laboratory research as well as a number of real-world situations including military operations, legal settings, and risk assessment. Prerequisite: any social science course, preferably PSYC-1200, or permission of instructor. Fall or spring term annually. 4 credit hours

STSS-4140 Inequality in America
Modern societies are characterized by varying degrees of social inequality or differences in education, income, wealth, status, and power. How large are these differences in the U.S.? What are their consequences? How are they created, and why do they persist? We examine such issues using social statistics, ethnographic accounts of people's lives, international comparative data, and theoretical writings on social class. Prerequisite: STSS-1210 or STSS-1110. Offered on availability of instructor. 4 credit hours

STSS-4200 China: Past and Present
An introduction to Chinese social organization and politics through readings in primary and secondary sources, class discussion, and student research projects. The class examines the paths of development open to China, and the problems the Chinese people face in choosing among them, along with the historical background of values, symbols, anger, and pride against which these issues are debated. Prerequisite: a course in STS or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4250 Human Dimensions of Biomedical Technologies
How do the products of biomedical technology affect us as taxpayers, patients, caregivers, technicians, inventors, and developers? The course considers the nature and scope of biomedical technology. Intensively studied are genetic intervention, in vitro fertilization, the artificial heart and kidney, computer diagnosis, medical imaging systems, adult and neonatal intensive care units, and transplantation. The unintended consequences of these biomedical fixes are explored. Prerequisite: STSH-1110/STSS-1110 or STSS-2100 or STSS-1210 or PSYC-1200 or PHIL-2500 or STSS-4260 or permission of instructor. Fall term annually. 4 credit hours
STSS-4260 Sociology of Medicine
This course explores the contributions of social science to the field of medicine. Following an historical and methodological introduction, the student follows the patient through the five stages of illness and medical care. Topics at each stage are discussed from the viewpoint of the patient, the medical care giver, and the health system. Students are encouraged, by means of a term paper, to explore areas that particularly interest them. Prerequisite: STSS-1210 or STSS-2100 or permission of instructor. Spring term annually. 4 credit hours

STSS-4270 The Social Relations of Science
All forms of knowledge and belief are products and reflections of social life. This course introduces and develops this idea for the case of science. The study of science as social relations serves as a vehicle for exploring the social nature of thinking and believing in general. Topics include laboratory culture, science and religion, gender and science, and science and democracy. Prerequisites: STSH-1110/STSS-1110 or STSS-1210 or STSS-1510. Spring term annually. 4 credit hours

STSS-4310 Politics of Science and Technology
An introduction to the processes by which society guides (and fails to guide) science and technology. Aspects of politics to be studied include Congress and the Presidency, courts, regulatory agencies, interest groups, business, media, and public opinion. Substantive topics include government support of scientific research, environmental regulations, NASA, advanced weaponry, robotics, and biotechnology. Prerequisite: any 2000-level STS course or permission of instructor. Annually. 4 credit hours

STSS-4320 Environmental Politics and Policy
A highly interactive introduction to environmental politics and policy in the United States. Major themes include the background and context of environmental politics and policy, the policy-making process, environmental issues selected and reported on by students, the varieties of environmentalism, and environmental ethics. Prerequisite: any 2000-level STS course or permission of instructor. Annually. 4 credit hours

STSS-4330 World Politics
Analysis of major political forces and policies of the principal nation-state groupings and leading powers that, on the one hand, reflect long-and short-range goals of these entities and, on the other hand, tend to promote stability or conflict in the international community. Prerequisite: STSS-1330 or permission of instructor. Fall term annually. 4 credit hours

STSS-4350 Politics of Design
A research seminar exploring the meaning of design in engineering, architecture, political theory, and other fields. How do social ideals and motives inspire design choices? To what extent does the design of human-made things shape the quality of public life? We study a variety of objects: buildings, machines, artifacts in everyday use, computer programs, political constitutions, etc. Prerequisites: any 2000-level course in STS or permission of instructor. Spring term odd-numbered years. 4 credit hours

STSS-4360 Contemporary Political Thought
This seminar focuses upon contemporary theoretical approaches to issues in political society. Writings in liberalism, conservatism, postmodernism, anarchism, and green politics are compared with special attention to their policy proposals. Prerequisite: any 2000-level STS course. Fall term alternate years. 4 credit hours

STSS-4390 Environment and International Policy
This course explores environmental issues that engage international attention and require new forms of policy and diplomacy. This course also explores the historical, cultural, and political-economic factors that contribute to contemporary concern about the environment. Particular attention is given to changing perceptions about the relationship between technological development, human welfare, and collective responsibility. Prerequisite: junior or senior status or permission of instructor. Annually. 4 credit hours

STSS-4400 Risky Technologies
Analyzes the political, social, and technical dimensions of civilian technologies perceived as potentially threatening to human health or the environment. Topics include chemical manufacturing, acid rain, pesticides, chemical and radioactive wastes, greenhouse effect, automobile safety, indoor air pollution, space flight, ozone, nuclear power, and other topics of interest to class members. Aspects of the political process studied include media, public opinion, risk perception, lobbying, scientific advice, Congress, President, courts, EPA and other regulatory agencies. Prerequisite: STSS-4310 or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4500 Environment and Development
This course surveys the actors, processes, and proposed solutions to the problems of environment and development. The theory and practice of three main themes are explored: the background and context of environment and development in North and South; politics and economic development in the South; and the problems and prospects for sustainable societies in North and South. Prerequisite: STSS-2300 or permission of instructor. Spring term alternate years. 4 credit hours

STSS-4530 Body: Self, Symbol, and Politics
Using cross-cultural comparisons, this course highlights the distinctive ways we conceptualize the body and explore how these assumptions influence health care in Western societies. The body is examined from three perspectives:
as experienced; as a natural symbol for thinking about the relationships between nature and society; and as an artifact of social and political control. Prerequisite: a 1000-level social science course. Offered on availability of instructor. 4 credit hours

STSS-4540 Environment, Law, and Culture
This course explores how culture influences the perception of environmental problems and the legal strategies relied on to solve them. The course also explores how environmental crisis challenges conventional ways of assessing and resolving social problems, requiring the innovation of new standards for establishing evidence, responsibility, and compensation. Case studies analyze historical change in the way the law operates, particularly with regard to threats to human health. Prerequisite: junior/senior status or permission of instructor. Spring term alternate years. 4 credit hours

STSS-4550 The Middle East through Native and Western Eyes
Using movies, newsreels, Middle Eastern fiction, and the writings of both Middle Eastern and Western anthropologists, we compare the ways Westerners and Middle Easterners see themselves. Topics include how the French and British viewed the countries of the Middle East they colonized, how the Arabs saw themselves and interpreted their struggles against colonialism, and how Americans perceive Middle Eastern events today. Prerequisite: a course in anthropology or permission of instructor. Offered on availability of instructor. Spring term annually. 4 credit hours

STSS-4560 Gender, Science, and Technology
“Sex” is the biological distinction between being male and female. “Gender” is the social construction of masculinity and femininity. The purpose of this course is to explore if, and if so, how, science and technology reciprocally contribute to and are shaped by gender ideals and images. We use gender as a tool for critical thinking about such topics as studies of sex differences, women in science and engineering, the environment, and war and peace. Prerequisite: STSH-1110/STSS-1110 or PHIL-2720/ STSH-2720 or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4570 Indian Politics and Culture
This course explores the roots and consequences of change in India, examining recent economic reforms, technological development, environmental crisis, increasing religious fundamentalism, poverty, population growth, and trends in literature, film, and art. The objective of the course is to provide students with a nuanced understanding of how social, cultural, and political-economic factors interact, complicating efforts to build sustainable modes of governance in the Third World. Fall term alternate years. 4 credit hours

STSS-4580 Modern Latin America
A general introduction to Latin American culture: history from the colonial era to the present; Afro-American, Native American, and Euro-Latin cultures as portrayed in literature and ethnography; and current issues, such as race and racism and development and the local populations. (Cross listed as STSH-4580. Students cannot obtain credit for both this course and STSH-4580.) Prerequisite: one H&SS course or permission of instructor. Offered on availability of instructor. 4 credit hours

STSS-4610 Twentieth-Century Germany
An introduction to the major events and issues in German history since 1914. The main focus is the interplay among politics, economics, and society in 20th-century Germany. Additional themes include the impact of war on society; the rich cultural legacy of the Weimar Republic; National Socialism's effects on political, economic, and cultural life; and continuity and change in German history. Prerequisite: a European history course or permission of instructor. Alternate years. 4 credit hours

STSS-4620 History of Medicine
Medical theory and practice are shaped both by culture and by prevailing disease patterns. The first half of this course surveys the history of Western medicine from Hippocrates until 1800. The second half of the course concentrates on 19th century and 20th century medicine, focusing in particular on developments in the United States. Prerequisite: a course in STS or permission of instructor. Spring term annually. 4 credit hours

STSS-4650 History of American Technology
Discusses the growth of American technology and its place within the framework of American history as well as the interrelationship of American and foreign technological developments. This course stresses the cultural contexts of technological change. Topics covered include the Erie Canal, the American system of manufacturing, railroads, emergence of engineering professions, corporate R&D, household technology, the technology of modern warfare, and the electronics revolution. Prerequisite: one course in American history or permission of instructor. Annually. 4 credit hours

STSS-4660 History of American Science
Examines scientific thought and institutions in the United States from the 18th to 20th centuries. Emphasizes on the interrelations between science and society from Benjamin Franklin and Thomas Jefferson to explorations of the West, the American reception of Darwinism, the Scopes Monkey trial, growth of the scientific-military-industrial complex, and the bomb. Prerequisite: STSH-1110/ STSS-1110 or one course in American history or permission of instructor. Annually. 4 credit hours
STSS-4670 History of Information Technology
This course will examine the social history of the information revolution, focusing on the post-World War II era. It explores the identity and cultural context of inventors and inventions, briefly surveying early mass communications, and then focusing on the first mainframes, the birth of cybernetics, the personal computer, and the Internet. Prerequisite: STSH-1110/STSS-1110 or one course in American history or permission of instructor. Annually. 4 credit hours

STSS-4800 Public Service/Professional Careers Internships
This course offers an insight into the public policy process from the vantage point of a part-time internship in the public or private sector as well as an opportunity to explore a career option before actually embarking upon it. The following is a partial list of the large number of possible internships: airport planning, architecture, banking, biological research, clinical psychology, computer science, consumer protection, corporate management, engineering, environmental planning, geology, local government, materials and mechanical engineering, noise pollution abatement, personnel management review, premedical, public finance and taxation, public health management, public relations, social work, state legislature, stock market, transportation planning, and urban planning. (Cross listed as STSH-4800.) Prerequisites: STSH-1110/STSS-1110; IHSS-1960; first year studies course or permission of instructor. Fall and spring terms annually. 4 credit hours

STSS-4900 Science, Technology and Society Seminar: Selected Topics
In seminar style, all participants have the opportunity to choose materials/topics and lead discussions. General topics vary each time the seminar is offered. We emphasize our own relationships in the community of science and technology studies. Restricted to S&S majors. Spring term annually. 4 credit hours

STSS-4920 Topics in Science, Technology and Society
Selected topics in science and society to meet the needs of science and society majors. Previous courses offered include Government, Business, Military, and Science; Ecology and Society; Cultural Dimensions of Clinical Medicine; Technological Innovation; Arms Control and Disarmament; Public Policy and Energy Development; World Energy Politics; Cultural History of Water in the USA; and Science, Technology, and Culture in China. Prerequisite: any 2000-level STS course or consent of instructor. 4 credit hours

STSS-4940 Readings in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology
With an individual faculty member on an agreed-upon topic. 4 credit hours

STSS-4960 Topics in Science and Technology Studies, Anthropology/Archaeology, History, Political Science, or Sociology 4 credit hours

STSS-4980 Senior Project
Ordinarily consists of independent research, supervised by a faculty member, culminating in a written thesis. A creative endeavor such as a videotape or computer program may be substituted with departmental permission. Restricted to S&S majors with senior standing. Fall, spring, and summer terms annually. 4 credit hours per term (maximum of 6 total)

STSS-6010, STSS-6020 Concepts/Research Seminar in Science and Technology Studies
A two-semester graduate seminar designed primarily for matriculants in the department’s M.S. program in Science and Technology Studies. Introduces students to the literature and the current issues in the constituent disciplines of Science and Technology Studies. Considers applications of this scholarship to current practical problems involving the human dimensions of science and technology. The first semester culminates in a bibliographic essay. In the second semester, students conduct research under the supervision of individual faculty members on topics of mutual interest. Prerequisite: graduate status or permission of instructor. Fall and spring terms annually. 3 credit hours each

STSS-6040 Technology and Social Theory
This seminar examines interactions between technology and society as seen from the vantage point of social and political theory. Careful reading of Marx, Mumford, Arendt, Foucault, and contemporary thinkers enables students to formulate their own ideas about the place of technology in human affairs. Alternate years. 3 credit hours

STSS-6100 Seminar in Science and Technology Policy
An overview of the field of public policy as applied to issues regarding science and technology. Primary attention is given to governmental institutions. Also analyzed are the corporate sector, technological momentum, cultural expectations, and perceptual processes. Criteria for judging desirability of options, together with conceptual approaches for understanding policy-making processes, are examined in diverse policy arenas, power, weaponry, and medical technology. Alternate years. 3 credit hours

STSS-6110 Research Methods in STS
This course offers an overview of social science techniques and research design and logistics and approaches widely used in STS. Fall term annually. 3 credit hours
STSS-6120 Advanced Research Methods
This course provides a foundation for professional-level research in science and technology studies. Through group research exercises, students explore the intersection between research issues (ethics, reliability, validity, quantification) and types of observation. Restricted to STS doctoral students or by permission. Alternate years. 3 credit hours

STSS-6200 Science and Social Theory
This seminar provides the resources and develops the skills needed for understanding, criticizing, constructing, and using theory in science studies. The seminar readings focus on major contributions to contemporary theory in science studies. Restricted to STS doctoral students or by permission. Alternate years. 3 credit hours

STSS-6300 Environment and Social Theory
This course focuses on contemporary social theory to understand the historical origins, institutional structures, and dominant trajectories of environmental-social change. Three main questions structure our inquiry into the links among science, technology, environment, and social theory: 1) why do modern societies degrade their environments? 2) why do environmental movements arise, or what are the social structural, cultural, and political origins of environmentalism? and 3) can some particular politics curtail environmental degradation? Fall term alternate years. 3 credit hours

STSS-6320 Advanced Environmental Politics and Policy
Conducted in conjunction with STSS-4320, with additional graduate-level readings and assignments. Spring term annually. 3 credit hours

STSS-6360 Advanced Contemporary Political Thought
Conducted in conjunction with STSS-4360, with additional graduate-level readings. Graduate students must write a research paper along with all other requirements for the course. Offered on the availability of instructor. 3 credit hours

STSS-6400 Environment and Health
This course explores how the health impacts of environmental problems are understood and responded to through medical, legal, and regulatory intervention. Case studies are used to highlight different strategies for dealing with environmental illness, comparing the perspectives of affected people, medical professionals, lawyers, government officials, industry representatives, and media. A core component of the course is devoted to problems related to exposure to toxic chemicals, including readings on popular epidemiology, mass torts, transboundary victimization and medical rehabilitation models. Fall term alternate years. 3 credit hours

STSS-6540 Advanced Environment, Law and Culture
Conducted in conjunction with STSS-4540, with additional graduate-level readings and assignments. Spring term alternate years. 3 credit hours

STSS-6560 Advanced Gender, Science, and Technology
Conducted in conjunction with STSS-4560. Additional graduate-level readings will focus on the impact of feminist theory on science and technology studies, and students are required to write a research paper. Offered on the availability of instructor. 3 credit hours

STSS-6600 Seminar in Ecological Economics, Values, and Policy
This introductory seminar in the Ecological Economics, Values, and Policy Professional Masters Program surveys the theories, methods, and world views of the approaches of ecological economics and science and technology studies to social scientific and humanistic environmental inquiry. Topics include: valuation, social construction, market failure, cultural studies, externalities, environmental policy and politics, Pareto optimality, and environmental ethics and philosophy. Fall term. 3 credit hours

STSS-6610 Western Science and Technology Since the Industrial Revolution
A graduate, seminar-style review of the extent interpretations of the history of science and technology in Western Civilization since the mid-1700s. Emphasis on historiographic mastery. Preparation of a bibliographic essay tailored to the student's concentration. Prerequisites: graduate standing in STS or permission of instructor. Alternate years. 3 credit hours

STSS-6650 Professional Project in Ecological Economics, Values, and Policy
The course focuses on the development of practical proposals for responding to environmental problems and opportunities. Research projects will include both primary data collection and the formulation of policy recommendations. Course readings will focus on case studies that involve disputes over environmental and economic issues, providing the basis for class discussion about how such disputes can be documented, analyzed and resolved through various scientific, legal, managerial, and policy initiatives. Prerequisites: EEVP Professional Masters Students or permission of instructor. Fall term. 3 credit hours

STSS-6940 Readings in Science and Technology Studies
With an individual faculty member on an agreed-upon topic. 1 to 3 credit hours

STSS-6960 Topics in Science and Technology Studies
Selected topics 3 credit hours
STSS-6970 Master's Internship  3 to 6 credit hours

STSS-6990 Master’s Thesis
Active participation in research, under the supervision of a faculty adviser, leading to a master’s thesis. Grades of IP are assigned until the thesis has been approved by the faculty adviser and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  1 to 9 credit hours

STSS-9990 Dissertation
Active participation in research, under the supervision of a faculty adviser, leading to a doctoral dissertation. Grades of IP are assigned until the dissertation has been publicly defended, approved by the doctoral committee, and accepted by the Office of Graduate Education to be archived in a standard format in the library. Grades will then be listed as S.  Up to 30 credit hours

USAF Air and Space Studies (ROTC)

USAF-0010, USAF-0080 Air Force Leadership Laboratory
The leadership laboratory courses (LLABs) include a study of Air Force customs and courtesies, drill and ceremonies, and military commands. The LLAB also includes studying the environment of an Air Force officer and learning about areas of opportunity available to commissioned officers. The AS 300 and AS 400 LLABs consist of activities classified as leadership and management experiences. They involve the planning and controlling of military activities of the cadet corps, and the preparation and presentation of briefings and other oral and written communications. LLABs also include interviews, guidance, and information which will increase the understanding, motivation, and performance of other cadets. An eight-semester (fall and spring) sequence, beginning each fall.  0 credit hours, 2 contact hours

USAF-1010, USAF 1020 Air and Space Studies 100 A and B (Foundations of the U.S. Air Force)
AS 100 is a survey course designed to introduce cadets to the United States Air Force and Air Force Reserve Officer Training Corps. Featured topics include: mission and organization of the Air Force, officerhood and professionalism, military customs and courtesies, Air Force officer opportunities, and an introduction to communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. 100 A (full term) 100 B (spring term)  1 credit hour

USAF-2030, USAF 2040 Air and Space Studies 200 A and B (The Evolution of USAF Air and Space Power)
The AS200 course designed to examine the general aspects of air and space power through a historical perspective. Utilizing this perspective, the course covers a time period from the first balloons and dirigibles to the space age global positioning systems of the Persian Gulf War. Historical examples are provided to extrapolate the development of Air Force capabilities (competencies), and missions (functions) to demonstrate the evolution of what has become today’s USAF air and space power. Furthermore, the course examines several fundamental truths associated with war in the third dimension: e.g., Principles of War and Tenets of Air and Space Power. As a whole, this course provides the cadets with a knowledge level understanding for the general element and employment of air and space power, from an institutional doctrinal and historical perspective. In addition, the students will continue to discuss the importance of the Air Force Core Values, through the use of operational examples and historical Air Force leaders, and will continue to develop their communication skills. Leadership Laboratory is mandatory for AFROTC cadets and complements this course by providing cadets with followership experiences. 200 A (fall term) 200 B (spring term)  1 credit hour

USAF-2050, USAF 2060 Air and Space Studies 300 A and B (Air Force Leadership Studies)
AS300 is a study of leadership, management fundamentals, professional knowledge, Air Force personnel and evaluation systems, leadership ethics, and the communication skills required of an Air Force junior officer. Case studies are used to examine Air Force leadership and management situations as a means of demonstrating and exercising practical application of the concepts being studied. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences in officer-type activities, giving students the opportunity to apply the leadership and management principles of this course. 300 A (full term) 300 B (spring term)  3 credit hours

USAF-2070, USAF 2080 Air and Space Studies 400 A and B (National Security Affairs and Preparation for Active Duty)
AS400 examines the national security process, regional studies, advanced leadership ethics, and Air Force doctrine. Special topics of interest focus on the military as a profession, officerhood, military justice, civilian control of the military, preparation for active duty, and current issues affecting military professionalism. Within this structure, continued emphasis is given to refining communication skills. A mandatory Leadership Laboratory complements this course by providing advanced leadership experiences, giving students the opportunity to apply the leadership and
USAR Military Science (ROTC)

USAR-1010 Fundamentals of Military Science I
The course introduces students to fundamental components of service as an officer in the United States Army. These initial lessons are the building blocks of progressive lessons in values, fitness, leadership, and officership. Additionally, the course addresses “life skills” including fitness, communications theory and practice (written and oral), and interpersonal relationships. Upon completion, students should be prepared to receive more complex leadership instruction. 1 credit hour

USAR-1020 Fundamentals of Military Science II
The course builds upon the fundamentals introduced in USAR-1010 by focusing on leadership theory and decision making. “Life skills” lessons in the semester include: problem solving, critical thinking, leadership theory, followership, group interaction, goal setting, and feedback mechanisms. Upon completion, students should be prepared to advance to more complex leadership instruction concerning the dynamics of organization. 1 credit hour

USAR-2010 Applied Leadership I
The course contains the principal leadership instruction of the Basic Course. The instruction delves into several aspects of communication and leadership theory. The use of practical exercise is emphasized, as students are increasingly required to apply communications and leadership concepts. Virtually the entire course teaches critical “life skills.” The relevance of these life skills to future success in the Army is emphasized throughout the course. The course concludes with a major leadership and problem-solving case study which draws on all of the classroom instruction received in the Basic Course. Upon completion of this semester, students should be well grounded in the fundamental principals of leadership, and be prepared to intensify the practical application of their studies during the Advanced Course. 1 credit hour

USAR-2020 Applied Leadership II
The course focuses principally on officership, providing an extensive examination of the unique purpose, roles, and obligations of commissioned officers. It includes a detailed look at the origin of the Army’s institutional values and their practical application in decision making and leadership. At the core is the Basic Course’s Capstone Case Study in Officership. This five lesson exercise traces the Army’s successes and failures as it evolved from the Vietnam War to the present, placing previous lessons on leadership and officership in a real world context that directly affects the future of the students who plan on attending the Advanced Course. This course, more than any before it, draws the various components of values, communications, decision making, and leadership together to focus on a career as a commissioned officer. Upon completion of this course, students should possess a fundamental understanding of both leadership and officership, and demonstrate the ability to apply this understanding in real-world situations. 1 credit hour

USAR-2060 Advanced Military Leadership
The course begins with instruction in the Leadership Development Program (LDP), used throughout the academic year to assess and develop leadership. Instruction in principles of war and purposes, fundamentals, and characteristics of the defense provides the necessary knowledge base for meaningful contextual treatment of Troop leading procedures (TLP). Instruction in decision-making, planning, and execution processes of the TLP are followed by a refocus on the critical leadership task of communicating the plan using the standard military format. The course addresses motivational theory and techniques, the role and actions of leaders, and risk assessment. The course closes with instruction in small unit battle drills to facilitate practice application and further leader development during labs and situational training exercises (STX). 2 credit hours

USAR-2070 Advanced Military Leadership II
The course continues to focus on doctrinal leadership and tactical operations at the small unit level. It includes opportunities to plan and conduct individual and collective skill training for military operations to gain leadership and tactical experience. The course synthesizes the various components of training, leadership and team building. Students are required to incorporate previous military science instruction for their practical application in a performance-oriented environment. Upon completion of the course, students will possess the fundamental confidence and competence of leadership in a small unit setting. 2 credit hours

USAR-4010 Advanced Military Management and Leadership I
The course concentrates on leadership, management and ethics. The course focuses students, early in the year, on attaining knowledge and proficiency in several critical areas they will need to operate effectively as Army officers. These areas include: coordinate activities with staffs, counseling theory and practice within the “army context,” training management, and ethics. While proficiency attained in each of these areas will initially be at the apprentice level, students will continue to sharpen these skills as they perform their roles as cadet officers within the ROTC program and after commissioning. At the end of the course, students
should possess the fundamental skills, attributes, and abilities to operate as competent leaders.

**USAR-4020 Advanced Military Management and Leadership II**
The course focuses on completing the transition from cadet to lieutenant. As a follow-on to the ethics instruction in USAR-400, the course starts with a foundation in the legal aspects of decision making and leadership. The curriculum reinforces previous instruction on the organization of the Army and introduces how the Army organizes for operations from the tactical to the strategic level. This is followed by instruction on administrative and logistical management that will focus on the fundamentals of soldier and unit level support. At the core of the semester is the Advanced Course Capstone Exercise. This 12-lesson exercise incorporates learning objectives from the entire military science curriculum. The capstone exercise will require students, both individually and collectively, to apply their knowledge to solve problems and confront situations commonly faced by junior officers. Upon completion of the course, students will be prepared for the responsibility of being a commissioned officer in the United States Army.

**USNA Naval Science (ROTC)**

*Note—students must have met certain academic and military training criteria; contact Military Science Department for determination.*

**USNA-0010–USNA-0080 Drill/Laboratory**
Consists of one period each week lasting approximately 2 hours. The periods are spent conducting various activities, including military drill, athletics, lectures and discussions on various topics of naval interest. Operating within a battalion organizational structure, students are given additional opportunities for leadership training and hands-on experience. An eight-semester (fall and spring) sequence, beginning each fall.

**USNA-1010 The Military and Its Place in Society**
The organization of the Department of Defense and the special role of ROTC. Concepts and strategy of national defense and the role of the military as an instrument of national power. The military in war and peace with emphasis on the traditional relationship between civil and military authority in the United States. Fall term annually.

**USNA-2020 Sea Power and Maritime Affairs**
A study in the development of the United States Navy and Marine Corps throughout the history of the United States. This course treats the broad principles, concepts, and elements of seapower with historical and modern applications to the United States and other world powers. Spring term annually.

**USNA-2030 Naval Leadership and Management I**
Comprehensive study of organization, leadership, and management with emphasis on the naval organization. Survey of the management process. Introduction to individual and small group behavior, decision making, responsibility, authority, and accountability. Extensive study of motivation, leadership, and communication. Application explored by case study and seminar discussions. Fall term annually.

**USNA-2040 Naval Ships Systems I**
A familiarization course in naval engineering. Study of types, structure, and purpose of naval ships. Elements of ship design to achieve safe operations and ship stability characteristics are examined. Ship compartmentation, propulsion systems, auxiliary power systems, ship control systems, and elements of damage control are included. Spring term annually.

**USNA-2050 Navigation**
The principles and procedures of ship navigation, movements, and employment. Course includes piloting, mathematical analysis, spherical triangulation, navigational aids, tides and currents, electronic navigation, and rules of the nautical road. Fall term annually.

**USNA-2060 Naval Operations**
An introduction to the complexities of modern naval operations. Course emphasis includes fleet communications and communication security, naval tactics, relative motion, maneuvering board, and ship operations and control. Spring term annually.

**USNA-2070 Naval Ships Systems II**
The study of weapons systems and the theoretical concepts underlying the design and operation of those systems. Includes sensor and detection subsystems, tracking systems, propulsion and guidance systems, launching systems, fire control problem solutions, and systems integration. In-depth analysis of representative, state-of-the-art weapons systems in use today. Fall term annually.

**USNA-2150 Evolution of Warfare**
A study of the forms of warfare practiced throughout history with the emphasis on those of the Middle East and Western Europe. Selected battles, strategy, formations, and commanders are studied from the times of the pharaohs to the present. The moral, ethical, and cultural attitudes of the times are brought into the course so that the student may understand how they influenced warfare and in turn were influenced by warfare. Spring term alternate years.

**USNA-2170 Amphibious Warfare**
The science of amphibious operations, emphasizing tacti-
WRIT-1110 Writing for Classroom and Career
This course emphasizes written, visual, and oral communication strategies that will help students succeed in both academic and professional contexts. Principal assignments are based on types of writing required in school and on the job: reporting, evaluating, taking a position, and making a proposal (orally and in writing). Written assignments will include visual elements such as headings, charts/graphs, and page or screen design. Fall and spring terms annually.

WRIT-1960 Topics in Writing
4 credit hours

WRIT-2110 Rhetoric and Writing
This course aims to increase students’ ability to develop ideas and to express them effectively. It gives special attention to expository and persuasive writing. Study of rhetorical theory and critical reading of speeches and/or essays help the students to understand the rhetorical process, to analyze the audience, and to foresee its response. A substantial amount of writing is required. Fall and spring terms annually.

WRIT-2310 Creative Writing
A workshop course in the practice of writing in one or more literary forms: poetry, drama, essay, fiction. Students work at their own pace and have opportunities to present their work for criticism by other students. The literary form featured during a given semester depends on the instructor. Spring term alternate years.

WRIT-2340 Speech Communication
This course focuses on developing public speaking skills and critical listening abilities. Guided by rhetorical theory, theories of persuasion, and argumentation theory, students prepare several oral presentations, engage in extemporaneous speaking exercises, and criticize other performances. Fall term annually.

WRIT-2360 Communication and Design
This course explores the communication processes of successful design teams, with a focus on how to create effective proposals, progress reports, final reports, and presentations. The course demonstrates the role of communication in design and provides guided practice in using various genres to communicate ideas verbally and visually. Helpful for students taking or planning to take capstone design or currently in design projects. Enrollment limit 25. Offered at least annually as staffing permits. 7 weeks.

WRIT-2410 Presentation Strategies
This course provides instruction and practice in making oral presentations. It focuses on creating and integrating visual aids (including the use of PowerPoint) analyzing and persuading an audience, and projecting an effective presence. Helpful for both beginning and experienced speakers. Enrollment limit 20. Offered fall and spring as staffing permits.

WRIT-2500 Writing for the World of Work
This course concerns the modes, techniques, and formats of writing that are most often used in professional environments. Students explore the assumptions that govern writing in their fields and practice the writing skills and styles applicable to communicating effectively. Includes some work in oral presentation strategies. Enrollment limit 25. Offered at least annually as staffing permits. 7 weeks.

WRIT-2510 Writing to the World Wide Web
This course provides an introduction to Web site design with emphasis on the design of text and hypertext for personal and organizational purposes. The course offers an introduction to basic principles of writing, visual design, and usability analysis in addition to Web technologies such as HTML, coding and image production and editing. Prerequisites: none. Junior or senior standing recommended. Fall and spring terms annually.

WRIT-2520 Writing: Print and Digital
This course emphasizes the repurposing of print text for use in interactive Web sites or CD-ROMs. The course links traditional writing skills (organization, style, audience, etc.) with new media skills such as information architecture. Annually.
WRIT-2960 Topics in Writing  
4 credit hours

WRIT-4120 Technical and Professional Communication  
Principles and practice of technical communication as applied to reports, technical papers, oral presentations, business communications, press releases, and popular articles. Limited to juniors, seniors, and graduate students. Fall and spring terms annually.  
4 credit hours

WRIT-4550 Proposing and Persuading  
Make things happen: start a business, raise funds, solicit work, support research, win a place on a conference program, take initiative, change the way things are done around here. This course will teach you how to write proposals that persuade. You will learn to turn situations into occasions for proposing, write a variety of proposals, locate Request for Proposals, develop a work-plan for feasible projects that come in on-time and on-budget, use networks to strengthen proposals, detail a budget, and edit for clarity and grace. Prerequisite: graduate standing or successful completion of a writing course. Fall term alternate years.  
4 credit hours

WRIT-4610 - Advanced Content Development for the World Wide Web  
This course is intended for those seeking a career in web design and analysis who wish to explore concepts of content development and management in depth. This studio-oriented course gives students a chance to analyze and create effective content for the web. Topics include how to create and maintain information structures for dynamic content and how to deliver customized content for specific user groups. Cross-listed with WRIT-4610. Students cannot obtain credit for both courses. Additional assignments at higher levels are required for those registered at the 6000 level. Fall term annually.  
3 credit hours

WRIT-4960 Topics in Writing  
4 credit hours

WRIT-6550 Proposing and Persuading  
Make things happen: start a business, raise funds, solicit work, support research, win a place on a conference program, take initiative, change the way things are done around here. This course will teach you how to write proposals that persuade. You will learn to turn situations into occasions for proposing, write a variety of proposals, locate Request for Proposals, develop a work-plan for feasible projects that come in on-time and on-budget, use networks to strengthen proposals, detail a budget, and edit for clarity and grace. Prerequisite: graduate standing or successful completion of a writing course. Fall term alternate years.  
3 credit hours

WRIT-6610 - Advanced Content Development for the World Wide Web  
This course is intended for those seeking a career in web design and analysis who wish to explore concepts of content development and management in depth. This studio-oriented course gives students a chance to analyze and create effective content for the web. Topics include how to create and maintain information structures for dynamic content and how to deliver customized content for specific user groups. Cross-listed with WRIT-6610. Students cannot obtain credit for both courses. Additional assignments at higher levels are required for those registered at the 6000 level. Fall term annually.  
3 credit hours
Administration

Office of the President
President ..................................................................................................................Shirley Ann Jackson
Secretary of the Institute and General Counsel .........................................................Charles F. Carletta
Associate Vice President for Policy and Planning,
Chief of Staff, and Assistant Secretary of the Institute ..................................................Cynthia R. McIntyre
Vice President and Dean, Rensselaer at Hartford ......................................................Alan C. Eckbreth
Institute Dean and Historian .......................................................................................Thomas Phelan

Rensselaer Technology Park and Commercial Real Estate Development
Director ...........................................................................................................Michael H. Wacholder

Office of Intellectual Property, Technology Transfer, and New Ventures
Executive Director ...........................................................................................................(vacant)
Director, Incubator Center .......................................................................................Simon Balint (Acting)
Director, Technology Commercialization ....................................................................Charles F. Rancourt

Human Resources
Vice President for Human Resources ...........................................................................Curtis N. Powell
Director, Employee Relations and Development .........................................................Beverly Pruitt
Manager, Compensation ...............................................................................................Anne Bilinsky
Manager, Benefits and Retirement .................................................................................Louis Padula
HRIS Coordinator .........................................................................................................Cindy Price
Director, Environmental Health and Safety .................................................................Cecile Mars

Office of the Provost
Provost ......................................................................................................................G.P. “Bud” Peterson
Vice Provost for Institute Diversity ...............................................................................Tom Apple (Interim)
Director, Academic Budgets and Planning ......................................................................Patricia Proper

Graduate Education
Vice Provost and Dean .................................................................................................Tom Apple
Associate Dean .............................................................................................................Dennis Gornic

Undergraduate Education
Vice Provost for Administration and Dean .....................................................................Gary A. Gabriele
Interim Director, Advising and Learning Assistance Center ...........................................Jeannie Steigler
Associate Director, Advising and Learning Assistance Center ........................................Nan Williams
Director, Anderson Center for Innovation in Undergraduate Education .....................Bradford C. Lister
Director, Institutional Research ......................................................................................Jack Mahoney
Faculty Ombudsperson for Academic Affairs ..................................................................(vacant)
Commanding Officer, Aerospace Studies ROTC .........................................................Col. Thomas D. Bell
Commanding Officer, Military Science ROTC ..............................................................Lt. Col. Thomas G. Donnelly
Commanding Officer, Naval Science ROTC .................................................................Capt. George D. Kasten, III

School of Architecture
Dean .............................................................................................................................Alan Balfour
Associate Dean .............................................................................................................Mark Mistur
School of Engineering
Dean .......................................................................................................................... William A. Baeslack III
Associate Dean ......................................................................................................... Robert W. Messler Jr.
Associate Dean ........................................................................................................ Lester A. Gerhardt
Director, Core Engineering ..................................................................................... Kevin Craig
Director, Women in Engineering Programs ............................................................ Barbara Ruel

School of Humanities and Social Sciences
Dean ........................................................................................................................... John P. Harrington
Associate Dean of Undergraduate Programs and Curriculum Initiatives .............. Lee Odell
Associate Dean of Graduate Programs and Research Initiatives ............................. Kim Fortun

Lally School of Management and Technology
Dean ............................................................................................................................ Denis F. Simon
Assistant Dean for Undergraduate Programs ......................................................... Robert Sands

School of Science
Dean .......................................................................................................................... Joseph E. Flaherty
Associate Dean ....................................................................................................... Samuel C. Wait Jr.
Associate Dean for Information Technology .......................................................... David Spooner

Enrollment Management
Dean ......................................................................................................................... Teresa C. Duffy
Assistant to the Dean/Office Manager ................................................................. Bonnie L. Skarka
Director, Enrollment Operations ........................................................................ Sharon M. Beaudoin
Director, Enrollment Planning .............................................................................. E. Jeanne Jenkins
Director, Undergraduate Enrollment Programs .................................................... Karen S. Long
Director, Enrollment Services ............................................................................... Glenna L. Ryan

Education for Working Professionals
Vice President and Dean, Rensselaer at Hartford .................................................. Alan C. Eckbreth
Assistant Dean for Strategy and Development ........................................................ Susan M. Bray
Director, Professional and Distance Education ..................................................... Kim A. Scalzo

Rensselaer at Hartford
Director of Admissions .......................................................................................... Rebecca M. Danchak
Registrar ................................................................................................................... Doris M. Matsikas
Financial Aid Officer, Veteran Affairs Coordinator ............................................... Gayle Hoffman
Controller ................................................................................................................ Margaret Huber
Manager, Human Resources and Financial Services ............................................. Natalie A. Sutera
Chief Information Officer ...................................................................................... Brian Clement
Director, The Cole Library ..................................................................................... Mary S. Dixey
Senior Enrollment Manager .................................................................................... Kristin Larity
Communications Manager ..................................................................................... Thomas J. Bittel
Director, Operations and Facilities ......................................................................... Paul J. Murphy
Director, Administrative Services .......................................................................... Kathleen A. Foley
Director, Professional Development Programs ....................................................... (vacant)
Student Services and Enrollment Administrator, Rensselaer Groton Site ............. Maria Angelos
Manager, Connecticut Quality Council .................................................................. Lynn LaChance (Acting)
Administration
Vice President for Administration.................................................................Claude D. Rounds

Auxiliary Services
Director ........................................................................................................Kathryn B. Edick
Manager, Conference Services/Houston Field House...............................Norris Pearson

Campus Planning and Facilities Design
Director ........................................................................................................Oliver S. Holmes Jr.
Manager, Engineering................................................................................Steven Angle
Manager, Design and Construction............................................................Edward M. Staats
Manager, Planning and Space Utilization..................................................J. Bruce Kunkel

Procurement and Financial Services
Director .........................................................................................................Paul W. Martin
Manager, Financial Services...................................................................Steven Schwan
Director, Administration Systems Support..............................................Mary Alice O'Brien
Director, Capital Analysis and Reporting................................................Donna B. Hoglund
Associate Director, Purchasing...............................................................Ann LoPonto
Associate Director, Small Business Procurement Services....................Eddie Jackson
Director, Real Estate................................................................................James M. Lyons
Manager, Administrative Services.............................................................Cathleen A. DiDio

Physical Plant
Director ........................................................................................................Mark A. Frost
Plant Engineer.............................................................................................Bruce C. Wyle
Senior Project Coordinator....................................................................Richard Hornberger
Supervisor, Campus Maintenance Center................................................Paul Galbraith
Manager, Facilities Automation..............................................................Richard P. Hilbert

Public Safety and Parking
Director (Parking and Access Control)......................................................Bernard C. Drobnicki
Assistant Director ......................................................................................Marc J. DelVecchio
Parking Coordinator................................................................................Carol Wagar

Environmental and Site Services
Director ........................................................................................................Scott A. Richards
Manager, Landscape Operations..............................................................Scott Litwin
Manager, Environmental Services............................................................Brian Kiel
Supervisor, Mail Services........................................................................David Heyward
Garage and Moving....................................................................................Joseph Flanigan
Athletic Fields.............................................................................................John Holstein

Rensselaer Dining Services (Sodexho Marriott)
General Manager.......................................................................................John Fusco
Operations Director....................................................................................Paul Keck
Director of Food Service Union...............................................................Robert McKeil
Director of Catering..................................................................................James Hollister

Division of the Chief Information Officer (DotCIO)
Chief Information Officer...........................................................................John E. Kolb
Director, Academic & Research Computing.............................................Sharon Roy
Director, IT Operations..............................................................................James Evans
Director, Networking & Communications.......................................................... John Bradley
Director, Integrated Administrative Computing Solutions ............................ Jeffrey Minor
Director, Research Libraries ........................................................................ Loretta Ebert
Director, Strategic Information Policy & Planning ....................................... John E. Kolb (Interim)
Director, Communications & Collaboration Technologies ........................ Gary Schwartz

Finance
Vice President for Finance ............................................................................. Virginia C. Gregg

Controller’s Office
Assistant Vice President and Controller ........................................................ Kirsten Volpi
Director, Accounting .................................................................................. Jeraldine Lake
Director, Disbursement Operations and Payroll ........................................... Pamela A. Rochminski
Director Research, Financial Administration .............................................. Diane Veros
Bursar ........................................................................................................... Sarah Ledermann
Lead Business Support Analyst .................................................................. Jackie Ellsworth

Capital Finance and Banking
Director ........................................................................................................ Christopher Berry

Financial Planning and Budget
Director ........................................................................................................ Eileen McLoughlin
Associate Director ...................................................................................... Helen Grzymala

Investments
Director ........................................................................................................ Travis Angevine
Investment Analyst ...................................................................................... Mark Larkin

Internal Auditing
Director ........................................................................................................ Vacant

Government and Community Relations
Vice President for Government and Community Relations ......................... Larry M. Snavley
Director, State Relations ............................................................................ John M. MacEnroe
Director, Community Relations .................................................................. Allison Newman

Institute Advancement
Vice President for Institute Advancement ..................................................... David S. Haviland

Advancement Strategy Services and Infrastructure
Assistant Vice President ................................................................................ David J. Bohan
Director, Advancement Communications & Business Intelligence ............. Janet Cooperman Hiser
Director, Advancement Events ................................................................... M. Paula Bentley
Operations Manager, Constituent Data Systems and Training .................... Marie K. Carroll
Associate Director, Special Programs ........................................................... Donna Anthus

Communications
Assistant Vice President ............................................................................... Jane Van Ryan
Director, Marketing ...................................................................................... Delcy Fox
Director, Media Relations ........................................................................... Theresa Bourgeois
Assistant Director, Media Relations .............................................................. Megan Galbraith
Director, University Events .......................................................................... Joe Michels
Senior Publications Editor ........................................................................... Tracey Leibach

Development and Alumni Relations
Assistant Vice President ............................................................................... Terri A. VanPatten
Acting Director, Alumni Relations ................................................................. Jeffrey Schanz
Associate Director, Alumni Relations.......................................................... Susan Haight
Director, Annual Giving ............................................................................... Lisa McGrath
Associate Director, Annual Giving ............................................................... Rita Fassett
Director, Individual and Organizational Advancement ................................ William A. Shumway
Director, Corporate Relations ..................................................................... Nancy Preston
Director, Foundation Relations .................................................................. Veronica Fitzgerald-Keady
Director, International Advancement ......................................................... Debra Geer

Research
Vice President ................................................................................................. Arthur C. Sanderson
Associate Vice President for Research ......................................................... Wolf W. von Maltzahn
Director of Research Development .............................................................. Ken S. Gertz

Contracts and Grants
Director ........................................................................................................... Richard E. Scammell
Assistant Director ........................................................................................ Patricia A. Gray

Student Life
Vice President for Student Life ................................................................. Eddie Ade Knowles
Executive Secretary ...................................................................................... Barbara L. Dean
Financial Manager ........................................................................................ Gina Ricci

Athletics
Director of Athletics ...................................................................................... Ken Ralph
Associate Director/Business .......................................................................... Kerry J. Quinn
Director of Women's Programs ..................................................................... Carol A. Pillsworth
Director of Intramurals .................................................................................. Karl Steffen
Assistant Director .......................................................................................... Mike Griffin
Assistant Director ........................................................................................... Joe King

Career Development Center
Director, Career Development Center ......................................................... Thomas L. Tarantelli
Senior Associate Director and Director, Cooperative Education .............. Diana Leis Delker
Associate Director ......................................................................................... Colleen O’Byrne
Career Counselor ............................................................................................ Todd Rutecki
Career Counselor ........................................................................................... Dawn Weaver
Career Counselor ............................................................................................ Angela Jones
Recruitment Coordinator ................................................................................ Alice Donohue

Dean of Students
Dean of Students ............................................................................................ Mark Smith
Associate Dean, Judicial Affairs ................................................................. Travis Apgar
Assistant Dean, International Services for Students & Scholars ................. Jane Havis
Assistant Dean, Greek Life .............................................................................. Brian Dominguez
Assistant Director/Operations Manager ......................................................... Jaye Vien
Associate Dean, Disabled Student Services ............................................... Debra Hamilton
Assistant Dean and Director, Office of Minority Student Affairs ...................(vacant)
Director Academic Support Programs ......................................................... Jeffrey Fryar
Assistant Dean of Students/Assistant Director, OMSA ......................... Olivette Sturges
Interim Assistant Dean and Director, Office of Minority Student Affiars .... Karen Ferrer-Muniz
Assistant Director for HEOP ........................................................................... Karen Ferrer-Muniz
Program Coordinator ................................................................. Gabriel Regal
Counselor ................................................................................ Adrienne Day

First Year Experience
Dean, First Year Experience ....................................................... Lisa Trahan
Assistant Dean ............................................................................ Annie Virkus
Assistant Dean ............................................................................ Cynthia Smith
Assistant Dean ............................................................................ Darlene Raysford

Health Services
Director .......................................................................................... Robert Athanasiou
Associate Director ........................................................................ Richard Many
Assistant Director .......................................................................... Monica Durviage
Director, Counseling Center ......................................................... Joseph Albert
Health Educator ............................................................................. Terry Kersch
Health System Manager ............................................................... Katrin Wesner

Religious Affairs
Coordinator, Religious Affairs and Resident Catholic Chaplain .......... Rev. Edward S. Kacerguis
Resident Catholic Chaplain .......................................................... Margaret Leathem
Associate Protestant Chaplain ....................................................... Beth Illingworth, Troy Area United Ministries
Hillel Adviser ................................................................................... Rabbi Aryeh Wineman
Imam of the Troy Mosque .............................................................. Djafer Sebkhaoui

Rensselaer Union
Director .......................................................................................... Rick Hartt
Coordinator, Mueller Center, Programs, and Club Sports ............. Steve Allard
Assistant Coordinator, Fitness Center, Programs, and Intramurals .......... Jessica Wasko
Coordinator, Strength and Weight Training ................................... Jon Rowan
Coordinator, Student Activities ..................................................... Cameron Reid McLean
Assistant Coordinator, Student Activities ......................................... Beth Carlile
Director, Business Operations and Bookstore ................................ Michael McDermott
Assistant Director, Business Operations and Bookstore ..................... Traci Griffin
Games Area Coordinator ............................................................... James Davidson
Finance Coordinator and Office Manager ...................................... Martha McElligott
Facilities Coordinator .................................................................. Jean Purcell
Accounting Tech ........................................................................... Cathy Ruff
Director, Young Actors Guild at Rensselaer ................................... Mary D’Amico
Coordinator, Rensselaer Model Railroad ..................................... John Nehrich

Archer Center for Student Leadership Development
Director ......................................................................................... Linda Teitelman McCloskey
Senior Educator/Lecturer .............................................................. Jane Reel
Senior Educator/Lecturer .............................................................. Christine Allard
Educator/Lecturer ........................................................................ Martha McCormick
Educator/Lecturer ........................................................................ Lisa Bugno
Educator/Lecturer ........................................................................ Catherine Persoon
Educator/Lecturer ........................................................................ Margaret Tong
Educator/Lecturer ........................................................................ Amy White
Educator/Lecturer ........................................................................ Valerie Sokol
Educator/Lecturer ........................................................................ Geisce Ly

Residence Life
Director ........................................................................................ Peter G. Snyder
Associate Director .........................................................................................................Melissa Powers
Assistant Director ......................................................................................................Scott Nonemaker
Assistant Director ................................................................................................Robert C. Armstrong
Assistant Director ...........................................................................................................Emily Bologna
Manager, Family Housing ..........................................................................................Beth Pasinella

Student Records and Financial Services
Registrar and Director, Student Records and Financial Services...............................Sharon L. Kunkel
Senior Associate Registrar ........................................................................................Maria Zanotta
Associate Registrar ...................................................................................................Peggy Conroy-Martin
Assistant Registrar .......................................................................................................Tracy Thomson
Assistant Registrar ...........................................................................................................Kim Herkert
Director of Financial Aid............................................................................................James H. Stevenson
Senior Associate Director ..........................................................................................Linda Parker
Associate Director ........................................................................................................Tracy Thomson
Assistant Director .........................................................................................................Lynette Crotty
Assistant Director .............................................................................................................Kim Herkert
Manager, Family Housing ..........................................................................................Beth Pasinella

Board of Trustees*

Officers
Samuel F. Heffner Jr. ’56 B.Arch., President, Dickinson-Heffner Inc., Chair
Arthur J. Gajarsa ’62 B.S., M.A., J.D., Judge, U.S. Court of Appeals the Federal Circuit, Vice Chair
Kenneth T. Lally Former President, Teledyne Gurley, Secretary
Shirley Ann Jackson B.S., Ph.D., D.L. (Hon.), D.Sc. (Hon.), NAE, President

Members
Stephen A. Barre ’60 B.S., MBA, Chairman, President, and Chief Executive Officer, Servo Corp. of America
Cornelius J. Barton ’58 B.S., M.S., Ph.D., Former President and Chief Executive Officer, Dorr-Oliver Inc.
Thomas R. Baruch ’60 B.M.T., J.D., General Partner, CMEA Ventures
Eugene K. Bolton B.A., Executive Vice President, U.S. Equity, General Electric Asset Management
Robert P. Bozzone ’55 B.S., M.S., Vice Chairman of the Board, Allegheny Teledyne Inc.
John H. Broadbent Jr. ’59 B.S., MBA, Director, Arrow International Inc.
George Campbell Jr. B.S., Ph.D., President, The Cooper Union for the Advancement of Science and Art
John W. Carr ’77 B.S., M.S., J.D./MBA, Partner, Simpson Thacher & Bartlett
Gary T. DiCamillo ’73 B.S., MBA, President and Chief Executive Officer, TAC Worldwide Companies
Nicholas M. Donofrio ’67 B.S., M.S., NAE, Senior Vice President, Technology and Manufacturing, IBM Corp.
Mary L. Good B.S., M.S., Ph.D., NAE, Dean, Donaghey College of Information Science and Systems Engineering, University of Arkansas at Little Rock
Michael E. Herman ’62 B.M.T., MBA, Herman Family Trading Company
David M. Hirsch ’65 B.E.E., MBA, President, Pawtucket Fasteners
Jeffrey L. Kodosky ’70 B.S., Vice President, National Instruments
Robin B. Martin ’71 B.S., M.S., D.H.L. (Hon), President and Chief Executive Officer, The Deer River Group
Francis L. McKone ’63 B.S., M.S., Former Chairman and Chief Executive Officer, Albany International Corp.
Nancy S. Mueller B.S., Founder, Nancy’s Specialty Foods
James C. Mullen ’80 B.S., MBA, President and Chief Executive Officer, Biogen Inc.
Mark Pattison B.S., M.S., Mayor of Troy, Ex Officio
Janet C. Rutledge ’83 B.S., M.S., Ph.D., Associate Dean of the Graduate School, University of Maryland, Baltimore County
Linda S. Sanford ’75 B.S., M.S., NAE, Senior Vice President, Enterprise on Demand Transformation, IBM Storage Systems Group
Paul J. Severino ’69 B.S., Founder and Former Chairman, Bay Networks
Paula L. Simon ’68 B.S., M.S., MBA, Chief Technology Officer, Wildlife Conservation Society
Jackson P. Tai ’72 B.S., MBA, President and Chief Operating Officer, The Development Bank of Singapore
Sheila Talton B.S., President, Change Management, EDS
G. Robert Tod ’61 B.M.E., MBA, Former President and Chief Operating Officer, CML Group Inc.
Ronald J. Zlatoper ’63 B.S., M.S., D.Eng. (Hon.), The Estate of James Campbell

Honorary Trustees
Harlan E. Anderson B.S., M.S., General Partner, Anderson Investment Co.
Harry Apkarian ’46 B.M.E., D.Sc. (Hon.), Chairman and Chief Executive Officer, Transtech Systems Inc.
Warren H. Bruggeman ’46 B.S., M.S., Former Vice President, General Electric Co.
Arnold Cogswell B.A.
Edward E. Hood Jr. B.S., M.S., NAE, Vice Chairman and Executive Officer, Retired, General Electric Co., Chair Emeritus
John T. Horton ’52 B.S., M.S., Ph.B. Philosophy
Howard P. Isermann ’42 B.S., Former Chairman and Chief Executive Officer, NOVAROME Inc.
Jack S. Parker B.S., D.B.A., L.D. (Hon.), NAE, Director Emeritus, Former Chairman and Executive Officer, General Electric Co.
John B. Reid ’25 B.S., MBA, Former Senior Vice President and Treasurer, Southern Pacific Co.
Carl J. Thomsen ’38 B.S., J.D. (Hon.), Hon. Fellow, Former General Director, Texas Instruments Inc.

Adjunct Trustees
Raymond A. Lancaster B.B.A., Managing Director, Candlewood Partners
Richard H. Stowe ’65 B.S., MBA, Capital Counsel
Robert O. Swanson ’58 B.S., Former Director and Executive Vice President, Mobil Corporation
Harvey L. Zeve ’52 B.Mgt.E., Chairman, H. L. Zeve Associates Inc.

Administrative Officers*
Shirley Ann Jackson B.S., Ph.D., D.L. (Hon.), D.Sc. (Hon.), NAE, President
Charles E. Carletta B.A., J.D., Secretary of the Institute and General Counsel
Virginia C. Gregg B.A., M.S., Vice President for Finance
David S. Haviland ’64 B.S., B.Arch., M.Arch., Vice President for Institute Advancement
Eddie Ade Knowles B.A., M.A., Ph.D., Vice President for Student Life
G.P. “Bud” Peterson B.S., M.S., Ph.D., Provost
Curtis N. Powell, SPHR B.S., M.S., Vice President for Human Resources
Claude D. Rounds, B.A., Vice President for Administration
Arthur C. Sanderson B.S., M.S., Ph.D., Vice President for Research
Larry M. Snavley B.A., M.A., J.D., Vice President for Government and Community Relations

*As of April 2003
Named Professorships

Rensselaer has several professorships honoring individuals or institutions for whom they are named, as well as honoring those who occupy them. These named professorships are listed below with their incumbents. Dates in parentheses indicate the year the professorship was established.

Ray Palmer Baker Distinguished Professorship (1997) .................................................................Toh-Ming Lu
Irene and Robert Bozzone '55 Assistant Professor of Management and Technology (1995) ...............(vacant)
Warren H. Bruggeman '46 and Pauline Urban Bruggeman
Distinguished Associate Professor (1995) ........................................................................................................Philip Phan
John A. Clark and Edward T. Crossan Professor of Engineering (1974) ....................................................(vacant)
Margaret A. Darrin Distinguished Professor in Applied Mathematics (1981) ...............................................(vacant)
Amos Eaton Professor of Computer Science (1991) ..................................................................................Joseph E. Flaherty
Ford Foundation Professor of Mathematics (1967) ....................................................................................Joyce R. McLaughlin
Frank and Lillian Gilbreth Professor in the Technologies
of Management (1969) ..................................................................................................................................Albert S. Paulson
Alma and H. Erwin Hale '30 Teaching Professorship of Humanities and Social Sciences (1991)Linda L. Layne
Edward P. Hamilton Distinguished Educator (1975) ....................................................................................Joseph G. Ecker
William Howard Hart Professor of Rational and Technical Mechanics (1883) ........................................George J. Dvorak
Wayne R. Hellman Chair (1996) ..................................................................................................................Mark S. Rea
John Tod Horton '52 Professor of Materials Engineering (1971) ..............................................................Martin E. Glicksman '57
Robert W. Hunt Professor of Materials Science and Engineering (1938) .....................................................Richard W. Siegel
Institute Professor of Nuclear Engineering (1981) .........................................................................................Don Steiner
Institute Professor of Science (1995) ...............................................................................................................E. Bruce Watson
Institute Professor of Science (1988) ..............................................................................................................Ivar Giaever '64
Institute Professor of Science and Technology (1983) ...................................................................................Daniel Berg
Howard P. Isermann '42 Professor of Chemical Engineering...........................................................................Jonathan Dordick
Samuel A. Johnson '37 and Elisabeth C. Johnson Professor in Engineering (1990) ........................................Mark S. Shephard
J. Erik Jonsson '22 Distinguished Professor (1997) .....................................................................................Xi-Cheng Zhang
Kodak Associate Professor in Environmental Engineering (1991) .............................................................James E. Kilduff
Louis Ellsworth Laflin Professor of English (1917) .......................................................................................Merrill D. Whitburn
New York State Science and Technology Foundation Professor
of Glass and Ceramics Science (1967) .........................................................................................................Robert H. Doremus
Thomas Phelan Chair in Humanities and Social Sciences (1995) ...............................................................(vacant)
Rosalind and John J. Redfern Jr. '33 Professor of Engineering (1981) ............................................................(vacant)
Eliza Ricketts Foundation Professor of Mathematics (1937) ....................................................................Donald A. Drew
Russell Sage Professor of Chemical Engineering (1938) .............................................................................Georges Belfort
Senior Constellation Professor, Biocatalysis and Metabolic Engineering ...................................................Robert J. Linhardt
Senior Constellation Professor, Future Chips ................................................................................................E. Fred Schubert
Philip Sporn Professor of Electric Power Engineering (1962) ....................................................................J. Keith Nelson
William Weightman Walker Professor of Chemistry (1905) ........................................................................(vacant)
William Weightman Walker Professor of Polymer Engineering (1905) .......................................................Sanford S. Sternstein '61
Cary L. Wellington Professor of the Management of Technology (1988) ....................................................(vacant)
Dean R. Wellington '83 Teaching Professorship in Management (1990) ...................................................Robert A. Baron
Yamada Corporation Professor (2001) ............................................................................................................James M. Tien '66
The Faculty

Faculty Roster
An asterisk (*) indicates recipients of the William H. Wiley Distinguished Faculty Award; a dagger † indicates recipients of the David M. Darrin Counseling Award; a double dagger †† indicates recipients of the Early Career Award.

Abbate-Gardner, Cinzia Adjunct Assistant Professor of Architecture; M.Arch. (University of Rome).

Abdoun, Tarek Research Assistant Professor of Civil and Environmental Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Abetti, Pier A. Clinical Professor, Lally School of Management and Technology; Ph.D. (Illinois Institute of Technology).

Aboul-Seoud, Mohamed Clinical Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (University of Louisville).

Abouzeid, Alhussein Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Washington, Seattle).

Abrajano, Teofilo A. Professor of Earth and Environmental Sciences; Ph.D. (Washington University, St. Louis).

Adali, Sibel Associate Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (University of Maryland).

Adams, Gary S. Professor of Physics; Ph.D. (Indiana University).

Adler, Michael Research Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).

Ajayan, Pulickel Professor of Materials Science and Engineering; Ph.D. (Northwestern University).

Akella, Srinivas Assistant Professor of Computer Science; Ph.D. (Carnegie Mellon University).

Akera, Atsushi Assistant Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (University of Pennsylvania).

Akpalu, Yvonne A. Assistant Professor of Chemistry; Ph.D. (University of Massachusetts, Amherst).

Amity, Michael Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Technion, Israel Institute of Technology).

Anderson, Kurt Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Stanford University).

Anderson-Gold, Sharon Professor of Science and Technology Studies, Ph.D. (New School for Social Research).

Andonie, John Assistant Professor of Military Science; B.S. (United States Military Academy, West Point).

Antal, Steven P. Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Apple, Thomas M. Dean of Graduate Education, Professor of Chemistry; Ph.D. (University of Delaware).

Arcak, Murat Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of California, Santa Barbara).

Azimi-Sadjadi, Babak Research Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Maryland).

Badger, Gregory L. Assistant Professor of Naval Science; B.S. (Rensselaer Polytechnic Institute).

Baeslack, William A., III Dean, School of Engineering; Professor of Materials Science and Engineering; P.E., Ph.D. (Rensselaer Polytechnic Institute).
Bahn, Curtis Associate Professor, Department of the Arts; Ph.D. (Princeton University).
Bailey, Ronald A. Acting Chair of Chemistry; Professor of Inorganic Chemistry; Member, Faculty of Information Technology; Ph.D. (McGill University).
Balfour, Alan Dean, School of Architecture; Professor of Architecture; M.F.A. (Princeton University).
Baron, Robert A. Dean R. Wellington '83 Teaching Professorship in Management; Professor, Lally School of Management and Technology; Professor of Psychology; Ph.D. (University of Iowa).
Bedard, Donna Research Professor of Biology; Ph.D. (University of Chicago).
Bedrosian, G. Clinical Associate Professor of Physics, Applied Physics, and Astronomy; Ph.D. (California Institute of Technology, Pasadena).
Belfort, Georges Russell Sage Professor of Chemical Engineering; Professor of Chemical Engineering; Ph.D. (University of California, Irvine).
Bell, David H. Associate Professor of Architecture; M.Arch. (University of Virginia).
Bell, Thomas D. Professor, Air and Space Studies; M.S. (University of Idaho).
Benicewicz, Brian C. Director, New York State Center for Polymer Synthesis; Professor of Chemistry; Ph.D. (University of Connecticut).
Bennett, Audrey Associate Professor of Language, Literature, and Communication; M.F.A. (Yale School of Art).
Bennett, Eric Assistant Professor of Military Science; M.P.A. (University of Colorado).
††Bennett, Kristin P. Associate Professor of Mathematical Sciences; Ph.D. (University of Wisconsin).
Benzing, Matthew Librarian (Information Systems); M.S.I.S. (University of Tennessee).
Bequette, B. Wayne Acting Chair, Chemical Engineering; Professor of Chemical Engineering; Ph.D. (University of Texas, Austin).
Berg, Daniel Institute Professor of Science and Technology; Professor of Decision Sciences and Engineering Systems; Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Yale University).
Berkley, Robyn A., Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Wisconsin, Madison).
Bhat, Ishwara B. Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Bizios, Rena Professor of Biomedical Engineering; Professor of Chemical Engineering; Ph.D. (Massachusetts Institute of Technology).
††Blanchet, Thierry A. Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Dartmouth College).
Bonner, Ellen D. Librarian, Coordinator/Technical Services; M.S.I.S. (Columbia University).
Bopp, Richard F. Associate Professor of Earth and Environmental Sciences; Ph.D. (Columbia University).
Borca-Tasciuc, Theodorian Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Los Angeles).
Boyce, Peter R. Research Professor of Architecture; Ph.D. (University of Reading, U.K.).
Boyer, Laura K. Clinical Assistant Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (McGill University).
Boylen, Charles W. Professor of Biology; Ph.D. (University of Wisconsin).
Breneman, Curtis M. Professor of Chemistry; Member, Faculty of Information Technology; Ph.D. (University of California, Santa Barbara).
Breyman, Steven J. Associate Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (University of California, Santa Barbara).
† Bringsjord, Selmer Chair and Professor of Cognitive Sciences; Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Brown University).
Bronet, Frances  Associate Dean and Professor of Architecture; M.S. (Columbia University).

Brunski, John B.  Professor of Biomedical Engineering; Ph.D. (University of Pennsylvania).

Burke LeFevre, Karen B.  Associate Professor of Rhetoric and Communication; Ph.D. (Rensselaer Polytechnic Institute).

Busch, Costas  Assistant Professor of Computer Science; Ph.D. (Brown University).

Bustamante, Nao  Assistant Professor of Arts; M.F.A. (San Francisco Art Institute).

Bystroff, Christopher  Assistant Professor of Biology; Ph.D. (University of California, San Diego).

Cale, Timothy S.  Professor of Chemical Engineering; Ph.D. (University of Houston, Texas).

Campbell, Nancy  Assistant Professor; Science and Technology Studies; Ph.D. (University of California, Santa Cruz).

Canier, Caren  Professor of Art; M.F.A. (Boston University).

Caporael, Linda R.  Professor of Psychology; Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (University of California, Santa Barbara).

Carlson, A. Bruce  Clinical Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (Stanford University).

Carothers, Christopher D.  Assistant Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Georgia Institute of Technology).

Carter, John  Edward P. Hamilton Clinical Faculty Fellow; Clinical Professor of Chemistry; Ph.D. (University of Oregon).

Casabella, Philip A.  Associate Chair of Physics, Applied Physics, and Astronomy; Professor of Physics; Ph.D. (Brown University).

Castillo, Luciano  Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (State University of New York, Buffalo).

Century, Michael L.  Chair, Department of Arts, Professor of Music; Ph.D. (University of Sussex).

Chang, Woojin  Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (Georgia Institute of Technology).

Cheney, Margaret  Professor of Mathematical Sciences; Ph.D. (Indiana University).

Cherniak, Daniele J.  Research Associate Professor of Earth and Environmental Sciences; Ph.D. (State University of New York at Albany).

Choi, Junho  Assistant Professor of Language, Literature, and Communication; Ph.D. (State University of New York, Buffalo).

Choma, Christin T.  Associate Professor of Chemistry; Ph.D. (University of Ottawa).

Choo, Adrian  Assistant Professor of Lally School of Management and Technology; Ph.D. (University of Minnesota).

Chow, Joe H.  Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; P.E., Ph.D. (University of Illinois).

Chow, T. Paul  Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Chung, Chan I.  Research Professor of Materials Science and Engineering; Ph.D. (Rutgers University).

Clesceri, Nicholas L.  Professor of Civil and Environmental Engineering; P.E., Ph.D. (University of Wisconsin).

Colón, Wilfredo  Assistant Professor of Chemistry; Ph.D. (Texas A&M University).

Connor, Kenneth A.  Chair and Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (Polytechnic Institute of New York).

Corbett, Andrew C.  Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Colorado, Boulder).
Craig, Kevin C. Director of Core Engineering; Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Columbia University).

† Cramer, Steven M. Professor of Chemical Engineering; Ph.D. (Yale University).

Crespo da Silva, Marcelo R.M. Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Stanford University).

Crivello, James V. Professor of Chemistry; Ph.D. (University of Notre Dame).

Cutler, Alan R. Professor of Chemistry; Ph.D. (Brandeis University).

DeAngelo, James R. Professor of Aerospace Studies; MBA (Webster University).

Danchak, Michael M. Clinical Professor of Computer Science and of Language, Literature, and Communication; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Danon, Yaron Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

De, Suhranu Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Member, Faculty of Information Technology; Ph.D. (Massachusetts Institute of Technology).

Deery, June E. Associate Professor of Literature; D.Phil. (Oxford University, England).


Demers, Diane, Research Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

DePaola, Natacha Associate Professor of Biomedical Engineering; Ph.D. (Harvard Medical School, Massachusetts Institute of Technology).

De Rosa, Andrew E. Assistant Professor of Aerospace Studies; M.S. (Wright State University).

Derby, Stephen J. Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Desrochers, Alan A. Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Purdue University).

Devereaux, Emile Clinical Assistant Professor of Arts; M.S. (University of California; San Diego).

Dickinson, Lael Clinical Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Diwan, Joyce J. Professor of Biology; Ph.D. (University of Illinois).

Dobry, Ricardo Professor of Civil and Environmental Engineering; Ph.D. (Massachusetts Institute of Technology).

Dojka, John F. Institute Archivist and Head, Collection Development; M.L.S. (Wayne State University).

Dordick, Jonathan S. Howard P. Isermann Professor of Chemical Engineering; Ph.D. (Massachusetts Institute of Technology).

Drew, Donald A. Chair, Mathematical Sciences; Eliza Ricketts Foundation Professorship of Mathematics; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Drineas, Petros Assistant Professor of Computer Science; Ph.D. (Yale University).

Duchin, Faye Professor of Economics; Ph.D. (University of California, Berkeley).

Duquette, David J. Chair and Professor, Department of Materials Science and Engineering; Ph.D. (Massachusetts Institute of Technology).

Durgée, Jeffrey F. Associate Professor, Lally School of Management and Technology; Ph.D. (University of Pittsburgh).

Dutta, Partha Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Indian Institute of Science, Bangalore, India).
Dvorak, George J. William Howard Hart Professor of Rational and Technical Mechanics; Professor of Mechanical, Aerospace, and Nuclear Engineering; Professor of Civil and Environmental Engineering; Ph.D. (Brown University).

Dyson, Anna Assistant Professor of Architecture; M.Arch. (Yale University).

Ebert, Loretta Director of Rensselaer Research Libraries; M.L.S. (State University of New York, Geneseo).

Ecker, Joseph G. Edward P. Hamilton Distinguished Professor; Professor of Mathematical Sciences; Professor of Decision Sciences and Engineering Systems; Ph.D. (University of Michigan).

Eglash, Ron Associate Professor of Science and Technology Studies; Ph.D. (University of California, Santa Cruz).

Ellinger, Jefferson Clinical Assistant Professor of Architecture; M.S. (Columbia University).

Embrechts, Mark J. Associate Professor of Decision Sciences and Engineering Systems and Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Member, Faculty of Information Technology; P.E., Ph.D. (Virginia Polytechnic Institute).

Erickson, David Assistant Professor of Military Science; B.A. (Siena College).

Esrock, Ellen J. Associate Professor of Literature; Ph.D. (New York University).

Fahey, James Clinical Assistant Professor of Cognitive Sciences; Ph.D. (State University of New York, Albany).

Fajen, Brett R. Assistant Professor of Cognitive Sciences; Ph.D. (University of Connecticut).

Feeseer, Larry J. Professor of Civil and Environmental Engineering; P.E., Ph.D. (Carnegie Mellon University).

Ferris, James P. Research Professor of Chemistry; Ph.D. (Indiana University).

Fish, Jacob Professor of Civil and Environmental Engineering; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Northwestern University).

Flaherty, Joseph E. Dean, School of Science; Amos Eaton Professor of Computer Science; Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (Polytechnic Institute of Brooklyn).

Fleisher, Sidney P. Adjunct Assistant Professor of Architecture; B.A. (Northeastern University).

Foley, William J. Clinical Associate Professor of Decision Sciences and Engineering Systems; P.E., Ph.D. (Rensselaer Polytechnic Institute).

Fontijn, Arthur Distinguished Research Professor of Chemical Engineering; D.Sc. (University of Amsterdam, Netherlands).

Fortun, Kim Associate Dean of Graduate Programs and Research Initiatives; Associate Professor of Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (Rice University).

Fortun, Michael Assistant Professor of Science and Technology Studies; Ph.D. (Harvard University).

Fouché, Rayvon D. Assistant Professor of Science and Technology Studies; Ph.D. (Cornell University).

Fox, William, Assistant Professor of Military Science.

Franklin, W. Randolph Associate Professor of Electrical, Computer, and Systems Engineering; Associate Professor of Computer Science; Ph.D. (Harvard University).

Freedman, Daniel Assistant Professor of Computer Science; Ph.D. (Harvard University).


Fulkerson, Robert E. Assistant Professor of Navel Science; B.S. (Arizona State University).

Gabriele, Gary A. Vice Provost for Administration; Dean of Undergraduate Education; Professor of Mechanical Engineering; Member, Faculty of Information Technology; Ph.D. (Purdue University).
Gall, Daniel  Assistant Professor of Materials Science and Engineering; Ph.D. (University of Illinois, Urbana-Champaign).

Garde, Shekhar  Assistant Professor of Chemical Engineering; Ph.D. (University of Delaware).

Gaska, Remis  Research Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Vilnius University, Lithuania).

Gearhart, Darrel  Assistant Professor of Military Science; M.S. (California University of Pennsylvania).

Geisler, Cheryl  Professor of Rhetoric and Composition; Ph.D. (Carnegie Mellon University).

Gerber, Lucien R.  Clinical Assistant Professor of French; Ph.D. (State University of New York, Albany).

Gerhardt, Lester A.  Associate Dean of Engineering; Professor of Electrical, Computer, and Systems Engineering; Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (State University of New York, Buffalo).

Gessmann, Thomas  Research Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Stuttgart).

Giaever, Ivar  Institute Professor of Science; Professor of Engineering Science; Ph.D. (Rensselaer Polytechnic Institute).

Gibson, David  Institute Professor of Science; Professor of Engineering Science; Ph.D. (Rensselaer Polytechnic Institute).

* Gill, William N.  Research Professor of Chemical Engineering; P.E., Ph.D. (Syracuse University).

Gillies, Charles W.  Associate Professor of Chemistry; Ph.D. (University of Michigan).

Gilpin, Joseph L.  Assistant Professor Air and Space Studies; M.A. (Webster University).

* Glicksman, Martin E. John Tod Horton  Professor of Materials Engineering; Professor of Chemical Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Glinert, Ephraim P.  Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (University of Washington).


Goebel, Johannes  Director, Experimental Media and Performing Arts Center; Professor of Music; M.A. (Staatliche Hochschule für Musik und Theater).

Goldberg, Mark K.  Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Mathematical Institute of the Academy of Science, Novosibirsk, USSR).

Golden, Timothy D.  Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Connecticut).

Goldenberg, David H.  Associate Professor, Lally School of Management and Technology; Ph.D. (University of Florida).

Gordon, Tamar  Associate Professor of Anthropology and Sociolinguistics; Ph.D. (University of California, Berkeley).

Gowdy, John M.  Professor of Economics; Member, Faculty of Information Technology; Ph.D. (West Virginia University).

Grabowski, Martha R.  Research Professor of Decision Sciences and Engineering Systems; Ph.D. (Rensselaer Polytechnic Institute).

Gray, Wayne D.  Professor of Cognitive Sciences; Ph.D. (University of California at Berkeley).

† Grice, Roger  Clinical Associate Professor of Technical Communication; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Grivas, Dimitri A.  Professor of Civil and Environmental Engineering; Ph.D. (Purdue University).

Gupta, Aparna  Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (Stanford University).

Gutmann, Juliette  Clinical Assistant Professor of Language, Literature, and Communication; Ph.D. (State University of New York, Albany).

* Gutmann, Ronald J.  Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).
† Haddock, Jorge Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Purdue University).

† Hagerup, Henrik J. Associate Professor of Aeronautical Engineering; Ph.D. (Princeton University).

Hahn, Tomie Assistant Professor of Music and Culture; Ph.D. (Wesleyan University).

Hajela, Prabhat Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Stanford University).

Halkias, Telemachus Chair and Professor of Military Science; M.S. (Naval Post Graduate School, Monterey, California).

Hanna, Michael H. Associate Professor of Biology; Member, Faculty of Information Technology; Ph.D. (University of Illinois).

Hannigan, Jeffrey Associate Professor of Science and Technology Studies; Member, Faculty of Information Technology; M.Arch. (Pratt Institute).

Hardwick, Martin Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Bristol University, U.K.).

Harrington, John P. Dean, School of Humanities and Social Sciences; Professor of Literature; Ph.D. (Rutgers University).

Hart-Davidson, William Assistant Professor of Language, Literature, and Communication; Member, Faculty of Information Technology; Ph.D. (Purdue University).

Hasan, Iftekhar Professor, Lally School of Management and Technology; Ph.D. (University of Houston).

Haviland, David S. Vice President for Institute Advancement; Professor of Architecture; M.Arch. (Rensselaer Polytechnic Institute).

Hayes, Timothy M. Professor of Physics; Ph.D. (Harvard University).

Heim, John Clinical Associate Professor of Economics; Member, Faculty of Information Technology; Ph.D. (University of Albany).

Hendrickson, Alan G. Assistant Professor of Naval Science; M.A. (Naval War College).

Heragu, Sunderesh S. Professor of Decision Sciences and Engineering Systems; Ph.D. (University of Manitoba, Canada).

Herron, Isom Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (Johns Hopkins University).

† Hess, David Chair, Department of Science and Technology Studies; Professor of Anthropology in Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (Cornell University).

High, Kathy Associate Professor of Science and Technology Studies; M.A.H. (State University of New York, Buffalo).

Hillig, William Research Professor of Materials Science and Engineering; Ph.D. (University of Michigan).

Hirsa, Amir Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of Michigan).

Holguin-Veras, Jose Associate Professor of Civil and Environmental Engineering; P.E., Ph.D. (University of Texas at Austin).

Hollingworth, David Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Minnesota).

Holmes, Colette Management Librarian; M.L.S. (State University of New York, Albany).

Holmes, Mark H. Professor of Mathematical Sciences; Ph.D. (University of California, Los Angeles).

Hopkins, Donna Engineering Librarian; M.L.S. (State University of New York, Buffalo).

Hsu, Cheng Professor of Decision Sciences and Engineering Systems; Member, Faculty of Information Technology; Ph.D. (Ohio State University).
Huang, Hanchen  Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Los Angeles)

Huang, Wesley H.  Assistant Professor of Computer Science; Assistant Professor of Electrical, Computer and Systems Engineering; Ph.D. (Carnegie Mellon University).

Hubbell, Christopher  Clinical Assistant Professor of Cognitive Sciences; Ph.D. (State University of New York, Albany).

Hübischer-Younger, Teresa  Assistant Professor of Language, Literature, and Communication; Member, Faculty of Information Technology; Ph.D. (Auburn)

Hudson, John B.  Professor of Materials Science and Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Hughes, Gregory N.  Clinical Professor of Economics; Clinical Professor of Decision Sciences and Engineering Systems; Clinical Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Princeton University).

Hults, Patricia  Digital Resources Librarian; M.L.S. (State University of New York at Albany).

Interrante, Leonard V.  Professor of Inorganic Chemistry; Ph.D. (University of Illinois, Urbana).

Isaacson, David  Professor of Mathematical Sciences; Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (New York University).

Jackson, Shirley Ann  President; Professor of Engineering; Professor of Physics, Applied Physics, and Astronomy; Member, Faculty of Information Technology; Ph.D. (Massachusetts Institute of Technology).

Jahng, JungJoo  Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Wisconsin, Milwaukee).

Jansen, Kenneth  Associate Professor of Mechanical Engineering; Assistant Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Stanford University).

Jayanthi, Shekhar  Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Minnesota).

Jennings, William C.  Vice Provost, Professional and Distance Education; Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Jensen, Michael K.  Professor of Mechanical Engineering; P.E., Ph.D. (Iowa State University).

Ji, Qiang  Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Washington).

Jones, Gregory  Assistant Professor of Military Science; M.S. (University of Missouri).

Judd, Gary  Professor, Lally School of Management and Technology; Professor of Materials Science and Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Kagan, Larry  Professor of Art; Member, Faculty of Information Technology; M.A. (State University of New York, Albany).

Kalsher, Michael J.  Associate Professor of Psychology; Member, Faculty of Information Technology; Ph.D. (Virginia Polytechnic Institute and State University).

Kalyanaraman, Shivkumar  Associate Professor of Electrical, Computer, and Systems Engineering; Assistant Professor of Computer Science; Ph.D. (Ohio State University).

Kaminski, Deborah A.  Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Kane, Ravi S.  Assistant Professor of Chemical Engineering; Ph.D. (Massachusetts Institute of Technology).
Kapila, Ashwani Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (Cornell University).

Kar, Kushik Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Maryland).

Kasten, George D., III Professor of Naval Science; B.S. (University of Utah).

Keblinski, Pawel Assistant Professor of Materials Science and Engineering; Ph.D. (Pennsylvania State University).

Keefe, Jeanne Assistant Librarian/Visual Resources; M.L.S. (State University of New York, Buffalo).

Kelly, Elizabeth Government Documents/Cataloguing Librarian; M.L.S. (State University of New York, Albany).

Kersting, Roland Assistant Professor of Physics; Ph.D. (University of Aachen).

Kettman, Vera M. Assistant Professor of Computer Science; Ph.D. (Cornell University).

Kiehl, Margaret (Maya) Edward P. Hamilton Clinical Faculty Fellow; Clinical Assistant Professor of Mathematical Sciences; Ph.D. (Rensselaer Polytechnic Institute).

Kilduff, James Kodak Associate Professor in Environmental Engineering; Associate Professor of Civil and Environmental Engineering; P.E., Ph.D. (University of Michigan).

Kim, Chan-Hyeong Research Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Texas A&M University).

Kliman, Gerald Research Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).

Kolb, John Chief Information Officer; Member, Faculty of Information Technology; P.E., M.Eng. (Rensselaer Polytechnic Institute).

Koller, John M. Professor of Cognitive Sciences; Ph.D. (University of Hawaii).

Komisar, Simeon Clinical Associate Professor of Civil and Environmental Engineering; Ph.D. (University of Washington).

Koratkar, Nikhil Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of Maryland, College Park).

Korenowski, Gerald M. Professor of Chemistry; Ph.D. (Cornell University).

Koretz, Jane F. Professor of Biology; Ph.D. (University of Chicago).

Korniss, Gyorgy Assistant Professor, Department of Physics, Applied Physics, and Astronomy; Member, Faculty of Information Technology; Ph.D. (Virginia Polytechnic Institute).

Kovacic, Gregor Associate Professor of Mathematical Sciences; Ph.D. (California Institute of Technology).

Kramer, Peter R. Assistant Professor of Mathematical Sciences; Ph.D. (Princeton University).

Krause, Sonja Professor of Physical Chemistry; Ph.D. (University of California, Berkeley).

Kreiger, Tanis Serials/Acquisitions Librarian; M.L.S. (State University of New York, Albany).

Krishnamoorthy, Mukkai S. Associate Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Indian Institute of Technology).

Krishnamurthy, Anath Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (University of Wisconsin-Madison).

Kroner, Walter M. Professor of Architecture; M.Arch. (Rensselaer Polytechnic Institute).

Kreuger, Ted, Associate Professor of Architecture; Member, Faculty of Information Technology; M. Arch. (Columbia University).

Krull, Robert Professor of Communication; Ph.D. (University of Wisconsin).

Kumar, Sanat Professor of Chemical Engineering; Ph.D. (Massachusetts Institute of Technology).

Lahey, Richard T., Jr. Edward E. Hood Jr. Professor; Professor of Mechanical, Aerospace, and Nuclear Engineering; Professor of Chemical Engineering; Professor of Mechanical Engineering; Member, Faculty of Information Technology; Ph.D. (Stanford University).
Lawrence, Charles Research Professor of Computer Science; Ph.D. (Cornell University).
Layne, Linda Alma and H. Erwin Hale ’30 Teaching Professorship of Humanities and Social Sciences; Professor of Anthropology in Science and Technology Studies; Ph.D. (Princeton University).
LeCoz, Yannick L. Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).
Lee, S. Research Professor of Physics; Ph.D. (University of Michigan).
Leifer, Richard P. Associate Professor, Lally School of Management and Technology; Professor of Decision Sciences and Engineering Systems; Member, Faculty of Information Technology; Ph.D. (University of Wisconsin).
Leslie, Russell P. Professor of Architecture; M.Arch. (Rensselaer Polytechnic Institute).
Li, C. James Professor of Mechanical Engineering; Ph.D. (University of Wisconsin, Madison).
Lim, Chjan C. Professor of Mathematical Sciences; Ph.D. (Brown University).
Linhardt, Robert J. Senior Constellation Professor, Biocatalysis and Metabolic Engineering, Professor of Chemistry; Ph.D. (John Hopkins University).
Linton, Jonathan Assistant Professor, Lally School of Management and Technology; Ph.D. (York University).
† List, George F. Chair and Professor of Civil and Environmental Engineering; Professor of Decision Sciences and Engineering Systems; Member, Faculty of Information Technology; P.E., Ph.D. (University of Pennsylvania).
Lister, Bradford Clinical Professor of Biology; Director, Center for Innovation in Undergraduate Education; Ph.D. (Princeton University).
Littman, Howard Research Professor of Chemical Engineering; Ph.D. (Yale University).
Lonsway, Brian Assistant Professor of Architecture; Member, Faculty of Information Technology; M. Arch. (Columbia University).
Lu, James Research Associate Professor of Physics, Applied Physics, and Astronomy; Research Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Technical University of Munich).
*† Lu, Tõh-Ming Associate Director, Center for Integrated Electronics; Ray Palmer Baker Distinguished Professor; Professor of Physics; Ph.D. (University of Wisconsin).
Luk, Franklin T. Professor of Computer Science; Ph.D. (Stanford University).
Lupulescu, Afina Research Associate Professor of Materials Science and Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Lvov, Yuri Assistant Professor of Mathematical Sciences; Ph.D. (University of Arizona).

Magdon-Ismail, Malik Assistant Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (California Institute of Technology).
Malaviya, Bimal K. Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Harvard University).
Malmberg, Charles J. Professor of Decision Sciences and Engineering Systems; Member, Faculty of Information Technology; Ph.D. (Georgia Institute of Technology).
Maniatty, Antoinette M. Associate Professor of Mechanical Engineering; Ph.D. (Cornell University).
Martin, Lealon Assistant Professor of Chemical Engineering; Ph.D. (University of California, Los Angeles).
Massie, W. Associate Professor of Architecture; Member, Faculty of Information Technology; M.Arch. (Columbia University).
Mayo, Robert R. Administrative Librarian; M.L.S. (State University of New York-Geneseo).
McCaffrey, Robert Professor of Earth and Environmental Sciences; Ph.D. (University of California, Santa Cruz).
McDaniel, Carl N. Professor of Biology; Ph.D. (Wesleyan University).
McDermott, Christopher  Associate Professor, Lally School of Management and Technology; Ph.D. (University of North Carolina, Chapel Hill).

McDonald, John F.  Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Yale University).

McIntyre, Cynthia R.  Clinical Associate Professor of Physics, Applied Physics, and Astronomy; Ph.D. (Massachusetts Institute of Technology).

McLaughlin, Harry W.  Professor of Mathematical Sciences; Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (University of Maryland).

McLaughlin, Joyce R.  Ford Foundation Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (University of California, Riverside).

Mercado, Alejandra  Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Maryland).

Messac, Achille  Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Massachusetts Institute of Technology).

Messler, Robert W.  Associate Dean of Engineering; Professor of Materials Science and Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Miccio, Ralph  Clinical Associate Professor, Lally School of Management and Technology; J.D. (Albany Law School).

Millard, Don L.  Director, Academy of Electronic Media; Research Associate Professor of Electrical, Computer, and Systems Engineering and of Electronic Arts; Ph.D. (Rensselaer Polytechnic Institute).

Miller, Branda  Professor of Arts; M.F.A. (New York University Graduate Film and Television Program).

Mistur, Mark S.  Clinical Associate Professor of Architecture; Member, Faculty of Information Technology; M.S., Building Conservation, B.Arch. (Rensselaer Polytechnic Institute).

Mitchell, John E.  Professor of Mathematical Sciences; Professor of Decision Sciences and Engineering Systems; Ph.D. (Cornell University).

Miyamoto, Paul  Clinical Assistant Professor of Language, Literature, and Communication; M.F.A. (Otis Art Institute).

Moore, James A.  Professor of Chemistry; Ph.D. (Polytechnic Institute of Brooklyn).

Morgan, Irvin W., Jr.  Clinical Assistant Professor, Lally School of Management and Technology; MBA (University of Chicago).

Murtagh, James P.  Clinical Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Murtuza, Syed  Clinical Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Purdue University).

Musser, David R.  Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (University of Wisconsin).

Myrabo, Leik N.  Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, San Diego).

Nadel, Alan  Professor of Literature; Ph.D. (Rutgers University).

Nagy, George  Professor of Electrical, Computer, and Systems Engineering; P.E., Ph.D. (Cornell University).

Nalamasu, Omkaram  Director, Center for Integrated Electronics; Professor of Materials Science and Engineering; Ph.D. (University of British Columbia)

Nambisan, Satish  Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Syracuse University).

Napolitano, James  Professor of Physics; Member, Faculty of Information Technology; Ph.D. (Stanford University).

Narendran, Nadarajah  Research Associate Professor in Architecture; Ph.D. (University of Rhode Island).
Nauman, E. Bruce  Professor of Chemical Engineering; Ph.D. (University of Leeds, England).

Nayak, Saroj K.  Assistant Professor of Physics; Ph.D. (Jawaharlal Nehru University, New Delhi).

Nelson, J. Keith  Phillip Sporn Professor of Electric Power Engineering; Professor of Electrical, Computer, and Systems Engineering; P.E., Ph.D. (University of London).

Nelson, Mark  Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (State University of New York, Albany).

Newberg, Heidi Jo  Associate Professor of Physics, Applied Physics, and Astronomy; Ph.D. (University of California, Berkeley).

Newberg, Lee  Research Associate Professor of Computer Science; Ph.D. (University of California, Berkeley).

Nierzwicki-Bauer, Sandra A.  Director, Darrin Fresh Water Institute; Professor of Biology; Member, Faculty of Information Technology; Ph.D. (University of New Hampshire).

Noble, Ralph G.  Associate Professor Cognitive Sciences; Ph.D. (University of California, Berkeley).

Nolan, Clifford J.  Research Assistant Professor of Mathematical Sciences; Ph.D. (Rice University).

Norsworthy, John R.  Professor, Lally School of Management and Technology; Ph.D. (University of Virginia).

Nyman, Marianne  Assistant Professor of Civil and Environmental Engineering; Ph.D. (Purdue University).

O’Connor, Gina  Assistant Professor, Lally School of Management and Technology; Ph.D. (New York University).

O’Rourke, Michael J.  Professor of Civil and Environmental Engineering; P.E., Ph.D. (Northwestern University).

Oatman, Michael  Clinical Assistant Professor of Architecture; M.F.A. (State University of New York, Albany).

Odell, C. Lee  Associate Dean of Undergraduate Programs and Curriculum Initiatives; Professor of Rhetoric and Composition; Ph.D. (University of Michigan).

Oliveros, P.  Distinguished Research Professor of Music; Doctor of Music (University of Maryland).

Ostrogorsky, Aleksandar G.  Professor of Mechanical, Aerospace, and Nuclear Engineering; Professor of Materials Science and Engineering; Sc.D. (Massachusetts Institute of Technology).

Ozisik, Rahmi  Assistant Professor of Materials Science and Engineering; Ph.D. (University of Akron).

Palazzo, Robert  Chair and Professor of Biology; Ph.D. (Wayne State University).

Parsons, Peter  Associate Professor of Architecture; B.Arch. (Cornell University).

Parsons, Robert H.  Associate Chair and Associate Professor of Biology; Member, Faculty of Information Technology; Ph.D. (Oregon State University).

Paulson, Albert S.  Frank and Lillian Gilbreth Professor in the Technologies of Management; Ph.D. (Virginia Polytechnic Institute).

Pearlman, William A.  Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Stanford University).

Peles, Yoav  Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Technion-Israel Institute of Technology).

Persans, Peter D.  Professor of Physics; Ph.D. (University of Chicago).

Peters, Lois S.  Associate Professor, Lally School of Management and Technology; Ph.D. (New York University).

Peterson, G. P. “Bud”  Provost; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D.
Phan, Phillip Warren H. Bruggeman ’46 and Pauline Urban Bruggeman Distinguished Associate Professor of Management; Member, Faculty of Information Technology; Ph.D. (University of Washington).

Phelan, Thomas Institute Dean; Senior Adviser to the President and Institute Historian; Professor of History; S.T.L. (Theological College of the Catholic University of America).

Picu, Caitlin Assistant Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Dartmouth College).

Piper, Bruce R. Associate Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (University of Utah).

Plawsky, Joel L. Professor of Chemical Engineering; Sc.D. (Massachusetts Institute of Technology).

Plopper, George E., Jr. Assistant Professor of Biology; Assistant Professor of Biomedical Engineering; Ph.D. (Harvard University).

Podowski, Michael Z. Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Warsaw Technical University).

Powell, Evelyn Constance Physical and Chemical Sciences Librarian; M.L.S. (State University of New York, Geneseo).

Puka, William J. Professor of Cognitive Sciences; Ph.D. (Harvard University).

Radke, Richard Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Princeton University).

Raghavachari, Madabhushi Professor of Decision Sciences and Engineering Systems; Ph.D. (University of California, Berkeley).

Rajan, Krishna Professor of Materials Science and Engineering; Member, Faculty of Information Technology; Sc.D. (Massachusetts Institute of Technology).

Ramanath, Ganapathiraman Associate Professor of Materials Science and Engineering; Ph.D. (University of Illinois, Urbana).

Ravichandran, T. Associate Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Southern Illinois University).

Rea, Mark S. Wayne R. Hellman Chair; Professor of Architecture; Professor of Psychology; Ph.D. (Ohio State University).

Reid, Larry D. Professor of Cognitive Sciences; Ph.D. (University of Utah).

Restivo, Sai Professor of Sociology in Science and Technology Studies; Ph.D. (Michigan State University).

Riebe, David Clinical Assistant Professor of Architecture; M.S. (Columbia University).

Robbins, R.W. Clinical Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; M.S. (Binghamton University).

† Roberge, Wayne G. Professor of Physics; Member, Faculty of Information Technology; Ph.D. (Harvard University).

Roecker, Steven W. Professor of Earth and Environmental Sciences; Ph.D. (Massachusetts Institute of Technology).

† Rolnick, Neil B. Professor of Music; Ph.D. (University of California, Berkeley).

Rosario, Alexander Assistant Professor of Naval Science; B.S. (George Mason University).

Roy, Harry Professor of Biology; Ph.D. (Johns Hopkins University).

Roysam, Badri Professor of Electrical, Computer, and Systems Engineering; Professor of Biomedical Engineering; Ph.D. (Washington University).

Roytburd, Victor Professor of Mathematical Sciences; Ph.D. (University of California, Berkeley).

Rubenfeld, Lester A. Professor of Mathematical Sciences; Ph.D. (New York University).
Ruiz, Kathleen H. Assistant Professor of Arts; M.F.A. (New York University).
Rupert, Amy P. Assistant Institute Archivist; M.L.S. (State University of New York, Albany).
Rusak, Zvi Professor of Aeronautical Engineering; D.Sc. (Technion-Israel Institute of Technology).
Ryu, Chang Assistant Professor of Chemistry; Ph.D. (University of Minnesota).

† St. John, William C. Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (Rensselaer Polytechnic Institute).
† Salerno, John C. Professor of Biology; Member, Faculty of Information Technology; Ph.D. (University of Pennsylvania).
Salon, Sheppard J. Professor of Electrical, Computer, and Systems Engineering; P.E., Ph.D. (University of Pittsburgh).
Sanderson, Arthur C. Vice President for Research; Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Carnegie Mellon University).
Sanderson, Susan Associate Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (University of Pittsburgh).
Sands, Robert Assistant Dean for Undergraduate Programs; Clinical Assistant Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; MBA (State University of New York, Albany).
Saulnier, Gary J. Associate Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).
Scarton, Henry A. Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Carnegie Mellon University).
Schadler, Linda Associate Professor of Materials Science and Engineering; Ph.D. (University of Pennsylvania).
Schmidt, David A. Clinical Assistant Professor of Mathematical Sciences; Ph.D. (Rensselaer Polytechnic Institute).
Schoch, Paul M. Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Schoelles, Michael Research Assistant Professor of Cognitive Sciences; Ph.D. (George Mason University).
Schowalter, Leo J. Professor of Physics; Ph.D. (University of Illinois).
Schroeder, John Professor of Physics; Ph.D. (Catholic University of America).
Schubert, E. Fred Senior Constellation Professor, Future Chips; Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Stuttgart, Germany).
Schwendeman, Donald W. Associate Professor of Mathematical Sciences; Ph.D. (California Institute of Technology).
Scott, Frances Y. Architecture Librarian; M.L.S. (Rutgers University).
Search, Patricia Professor of Graphics; M.A. (Goddard College).
Senkevich, J. Research Assistant Professor of Physics, Applied Physics, and Astronomy; Ph.D. (Rensselaer Polytechnic Institute).
Sharfstein, Susan Assistant Professor of Chemical Engineering; Ph.D. (University of California, Berkeley).
Sharma, Anurag Assistant Professor of Earth and Environmental Sciences; Ph.D. (State University of New York at Binghamton).
Shepherd, Mark S. Director, Scientific Computation Research Center; Samuel A. Johnson ’37 and Elizabeth C. Johnson Professor in Engineering; Professor of Civil and Environmental Engineering; Professor of Mechanical, Aerospace, and Nuclear Engineering; Professor of Computer Science; P.E., Ph.D. (Cornell University).
Shima, Mutsuhiro Assistant Professor of Materials Science and Engineering; Ph.D. (University of
Maryland).

Shur, Michael Patricia W. and C. Sheldon Roberts ’48 Chaired Professor in Solid State Electronics; Professor of Electrical, Computer, and Systems Engineering; Professor of Physics, Applied Physics and Astronomy; Ph.D. (A.F. Ioffe Institute of Physics and Technology, Soviet Union).

Shur, Paulina Clinical Associate Professor of Arts; M.F.A. (University of Virginia).

Shuster, Edward L. Research Assistant Professor of Earth and Environmental Sciences; Ph.D. (Rensselaer Polytechnic Institute).

Sieg, Donald S. Chair and Professor of Economics; Ph.D. (Columbia University).

Sieg, Richard W. Director, Rensselaer Nanotechnology Center; Robert W. Hunt Professor of Materials Science and Engineering; Professor of Materials Science and Engineering; Member, Faculty of Information Technology; Ph.D. (University of Illinois).

Siegmann, William L. Professor of Mathematical Sciences; Member, Faculty of Information Technology; Ph.D. (Massachusetts Institute of Technology).

Sikdar, Biplab Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Simon, Denis Dean and Professor, Lally School of Management and Technology; Ph.D. (University of California, Berkeley).

† Simons, Gene R. Associate Dean and Professor, Lally School of Management and Technology; Ph.D. (Rensselaer Polytechnic Institute).

Simons, Kenneth Assistant Professor of Economics; Ph.D. (Carnegie-Mellon University).

Slack, Glen Research Professor of Physics; Ph.D. (Cornell University).

Slovacek, Rudolf E. Research Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Smith, Richard N. Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (University of California, Berkeley).

Smith, Susan M. E. Clinical Assistant Professor of Biology; Ph.D. (Rensselaer Polytechnic Institute).

Sneck, Henry Clinical Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Spear, Frank S. Chair and Professor of Earth and Environmental Sciences; Ph.D. (University of California, Los Angeles).

Sperber, Daniel Professor of Physics; Ph.D. (Princeton University).

Spilker, Robert L. Chair and Professor of Biomedical Engineering; Professor of Mechanical, Aerospace, and Nuclear Engineering; Sc.D. (Massachusetts Institute of Technology).

Spooner, David L. Associate Dean for Information Technology; Professor of Computer Science; Member, Faculty of Information Technology; Ph.D. (Pennsylvania State University).

Staniszewski, MaryAnn Associate Professor of Arts; Ph.D. (City University of New York).

Stegemann, J.P. Assistant Professor of Biomedical Engineering; Ph.D. (Georgia Institute of Technology).

Steinbruchel, Christoph Associate Professor of Materials Science and Engineering; Ph.D. (University of Minnesota).

Steiner, Don Institute Professor of Nuclear Engineering; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Massachusetts Institute of Technology).

Steiner, Mark Director, Multidisciplinary Design Laboratory; Clinical Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Stenken, Julie Associate Professor of Chemistry; Ph.D. (University of Kansas).

Stephanou, Harry Director, Center for Automation Technologies; Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Purdue University).

Stephens, Irving E. Librarian; Coordinator, Public Services; M.L.S. (State University of New York,
Stern, David Associate Professor of Economics; Ph.D. (Boston University).
Sternstein, Sanford S. William Weightman Walker Professor of Polymer Engineering; Professor of Materials Science and Engineering; Ph.D. (Rensselaer Polytechnic Institute).
Stewart, Charles Professor of Computer Science; Ph.D. (University of Wisconsin).
Stoler, Paul Professor of Physics; Ph.D. (Rutgers University).
Strait, Kerry L. Assistant Professor of Aerospace Studies; M.B.A. (Johns Hopkins University).
Sullo, Pasquale Associate Professor of Decision Sciences and Engineering Systems; Ph.D. (Florida State University).
Sun, Jian Associate Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Paderborn).
Swersey, Burt L. Senior Lecturer in Mechanical, Aerospace, and Nuclear Engineering; B.S. (Cornell University).
Symans, Michael Associate Professor of Civil and Environmental Engineering; Ph.D. (State University of New York, Buffalo).
Szymanski, Boleslaw K. Professor of Computer Science; Ph.D. (Polish Academy of Sciences, Warsaw, Poland).
Thornton, Karen Assistant Professor of Arts; Member, Faculty of Information Technology; M.F.A. (Art Institute of Chicago).
Tichy, John A. Chair and Professor of Mechanical, Aerospace, and Nuclear Engineering; Member, Faculty of Information Technology; Ph.D. (University of Michigan).
Tien, James M. Yamada Corporation Professor; Chair and Professor of Decision Sciences and Engineering Systems; Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).
Tiersten, Harry F. Professor of Mechanics, Department of Mechanical, Aerospace, and Nuclear Engineering; P.E., Ph.D. (Columbia University).
Tomozawa, Minoru Professor of Materials Science and Engineering; Ph.D. (University of Pennsylvania).
Torres, Rendell Assistant Professor of Architecture; Member, Faculty of Information Technology; Ph.D. (Chalmers Teleniska Hogskola, Sweden).
Traver, Holly A. Research Associate Professor of Cognitive Sciences; Ph.D. (State University of New York, Albany).
Trinkle, Jeffrey C. Chair and Professor of Computer Science; Ph.D. (University of Pennsylvania).
Triscari, Thomas Clinical Associate Professor, Lally School of Management and Technology; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).
Vamos, Igor Assistant Professor of Arts; M.F.A. (University of California, San Diego).
VanDessel, Steven Assistant Professor of Architecture; Ph.D. (University of Florida, Gainesville).
Varela, Carlos A. Assistant Professor of Computer Science; Ph.D. (University of Illinois at Urbana-Champaign).
Vashishth, Deepak Assistant Professor of Biomedical Engineering; Ph.D. (University of London).
Vastola, Kenneth S. Professor of Electrical, Computer, and Systems Engineering; Member, Faculty of Information Technology; Ph.D. (University of Illinois).
Veryzer, R. Associate Professor, Management Policy and Organization; Ph.D. (University of Florida).
Vitaliano, Donald F. Professor of Economics; Ph.D. (City University of New York).
von Maltzahn, Wolf  Associate Vice President for Research; Professor of Biomedical Engineering; Ph.D. (University of Hannover, Germany).

Vostral, Sharra  Assistant Professor of Science and Technology Studies; Ph.D. (Washington University).

Wait, Samuel C., Jr.  Associate Dean, School of Science; Professor of Physical Chemistry; Ph.D. (Rensselaer Polytechnic Institute).

Walczyk, Daniel  Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; P.E., Ph.D. (Massachusetts Institute of Technology).

Wallace, William A.  Professor of Decision Sciences and Engineering Systems; Professor of Civil and Environmental Engineering; Professor of Cognitive Sciences; Member, Faculty of Information Technology; Ph.D. (Rensselaer Polytechnic Institute).

Waltz, Mary Anne  Librarian Coordinator, Reference/Instructional Services; M.L.S. (Syracuse University).

† Wang, Gwo-Ching  Chair, Department of Physics, Applied Physics and Astronomy; Professor of Physics; Ph.D. (University of Wisconsin).

Warden, Joseph T.  Professor of Chemistry; Ph.D. (University of Minnesota).

Wark, David A.  Research Associate Professor of Earth and Environmental Sciences; Ph.D. (University of Texas, Austin).

Warriner, Kenneth L., Jr.  Associate Professor of Architecture; B.Arch. (University of Florida).

Washington, Morris A.  Associate Director, Center for Integrated Electronics; Clinical Professor of Physics, Applied Physics, and Astronomy; Ph.D. (New York University).

† Watson, E. Bruce  Institute Professor of Science; Professor of Earth and Environmental Sciences; Ph.D. (Massachusetts Institute of Technology).

Watt, James  Chair and Professor, Department of Language, Literature, and Communication; Ph.D. (University of Wisconsin, Madison).

Wayner, Peter C., Jr.  Distinguished Research Professor of Chemical Engineering; Ph.D. (Northwestern University).

Wen, John Ting-Yung  Professor of Electrical, Computer, and Systems Engineering; Professor of Mechanical, Aerospace, and Nuclear Engineering; Ph.D. (Rensselaer Polytechnic Institute).

Wentland, Mark P.  Professor of Chemistry; Ph.D. (Rice University).

Whitburn, Merrill D.  Louis Ellsworth Laffin Professor of English; Professor of Communication and Rhetoric; Ph.D. (University of Iowa).

Whittet, Douglas C.B.  Professor of Physics; Ph.D. (St. Andrews University, Scotland).

Wiedemeier, Heribert A.  Research Professor of Physical Chemistry; D.Sc. (University of Muenster).

Wilke, Ingrid  Assistant Professor of Physics; Ph.D. (Swiss Federal Institute of Technology).

Willemain, Thomas R.  Professor of Decision Sciences and Engineering Systems; Member, Faculty of Information Technology; Ph.D. (Massachusetts Institute of Technology).

Winner, Langdon  Professor of Political Science, Science and Technology Studies; Ph.D. (University of California, Berkeley).

Wolff, William S.  Professor and Chair of Naval Science; M.S.E. (Catholic University of America).

Woodhouse, Edward J.  Associate Professor of Political Science, Science and Technology Studies; Member, Faculty of Information Technology; Ph.D. (Yale University).

Woods, John W.  Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Massachusetts Institute of Technology).

Wozny, Michael J.  Professor of Electrical, Computer, and Systems Engineering; Professor of Computer Science; Ph.D. (University of Arizona).

Wright, Roger N.  Professor of Materials Science and Engineering; P.E., Sc.D. (Massachusetts Institute of Technology).
Xu, George Associate Professor of Mechanical, Aerospace, and Nuclear Engineering; Associate Professor of Biomedical Engineering; Ph.D. (Texas A&M University).

Xu, Jiahua Assistant Professor of Biology; Ph.D. (Meharry Medical College).

Yang, Yingrui Assistant Professor of Cognitive Sciences; Assistant Professor of Decision Sciences and Engineering Systems; Ph.D. (New York University).

Yazici, Birsen Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Purdue University).

Young, Nicholas M. Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Chicago).

Yu, Thomas Pok-Yin, Assistant Professor of Mathematical Sciences; Ph.D. (Stanford University).

Zaki, Mohammed Assistant Professor of Computer Science; Ph.D. (University of Rochester).

Zallnick, Deidre A. Assistant Professor, Naval Sciences; B.S. (U.S. Naval Academy).

Zappen, James P. Associate Professor of Communication and Rhetoric; Ph.D. (University of Missouri).

Zaretsky, Adam Clinical Assistant Professor of Electronic Art; M.F.A. (University of Art Institute of Chicago).

Zeghal, Mourad Assistant Professor of Civil and Environmental Engineering; Ph.D. (Princeton University).

Zimmer, Michael J., Jr. Professor of Cognitive Sciences; Ph.D. (Rensselaer Polytechnic Institute).

Zhang, Tong Assistant Professor of Electrical, Computer, and Systems Engineering; Ph.D. (University of Minnesota).

† Zhang, Xi-Cheng J. Erik Johnsson’22 Distinguished Professor; Director, Center for Terahertz Research; Professor of Physics; Professor of Electrical, Computer, and Systems Engineering; Ph.D. (Brown University).

Zuker, Michael Professor of Mathematical Sciences; Professor of Biology; Ph.D. (Massachusetts Institute of Technology).

Faculty Roster (Rensselaer at Hartford)

Albright, Robert R., II Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (University of Pittsburgh).

Arnheiter, Edward D. Clinical Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Massachusetts).

Bragaw, Louis K., Jr. Clinical Professor, Lally School of Management and Technology; D.B.A. (George Washington University).

Brown, Roger H. Clinical Assistant Professor, Department of Engineering and Science; Member, Faculty of Information Technology; M.S.E.E. (University of Illinois).

Chase, Robin Clinical Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Southern California).

DeNoia, Lynn A. Clinical Professor, Department of Engineering and Science; Member, Faculty of Information Technology; Ph.D. (Brown University).

Eckbreth, Alan C. Vice President and Dean; Professor, Department of Engineering and Science; Ph.D. (Princeton University).
Ellis, Heidi J. C. Clinical Associate Professor, Department of Engineering and Science; Member, Faculty of Information Technology; Ph.D. (University of Connecticut).

Emiliani, Mario L. Clinical Professor, Lally School of Management and Technology; Ph.D. (Brown University).

Fransson, Martha C. Clinical Associate Professor, Lally School of Management and Technology; MBA (Dartmouth College).

Gingerella, Louis W., Jr. Clinical Associate Professor, Lally School of Management and Technology; MBA (Rensselaer Polytechnic Institute).

Grasso, Lawrence P. Clinical Associate Professor, Lally School of Management and Technology; DBA (Boston University).

Gutierrez-Miravete, Ernesto Interim Associate Chair and Clinical Associate Professor, Department of Engineering and Science; Ph.D. (Massachusetts Institute of Technology).

Hartley, Timothy J. Clinical Associate Professor; Department of Engineering and Science; Member, Faculty of Information Technology; M.S. (University of Connecticut).

Hodges, James L. Clinical Professor, Department of Engineering and Science; Ph.D. (Stevens Institute of Technology).

Ilovici, Irina Clinical Assistant Professor, Lally School of Management and Technology; Ph.D. (University of Connecticut).

Jenkins, Frank C. Clinical Associate Professor, Lally School of Management and Technology; MBA (University of Pennsylvania).

Kelly, Leonard J. Clinical Professor, Lally School of Management and Technology; Ph.D. (University of Connecticut).

Klein, Hans E. Clinical Associate Professor, Lally School of Management and Technology; D.B.A. (University of Kentucky).

LaPlaca, Peter J. Clinical Professor, Lally School of Management and Technology; Ph.D. (Rensselaer Polytechnic Institute).

Luddy, William J., Jr. Clinical Professor, Lally School of Management and Technology; J.D. (University of Connecticut).

Maleyeff, John Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (University of Massachusetts).

Martyn, Timothy O. Clinical Associate Professor, Department of Engineering and Science; Member, Faculty of Information Technology; Ed.D. (University of Massachusetts).

McKim, James C., Jr. Interim Chair and Clinical Professor, Department of Engineering and Science; Member, Faculty of Information Technology; Ph.D. (University of Iowa).

Mesiya, M. Farooque Clinical Associate Professor, Department of Engineering and Science; Ph.D. (Queens University, Canada).

Olson, Peter W. Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (Columbia University).
Peteros, Randall G. Clinical Assistant Professor, Lally School of Management and Technology; J.D. (Western New England College School of Law).

Rainey, David L. Chair, Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (Rensselaer Polytechnic Institute).

Schroth, Peter W. Clinical Professor; Lally School of Management and Technology; S.J.D., (University of Michigan).

Slangen, Guido H. Associate Chair, Clinical Professor, Lally School of Management and Technology; Ed.D. (University of Massachusetts).

Stodder, James P. Clinical Associate Professor, Lally School of Management and Technology; Ph.D. (Yale University).

Younessi, Houman Clinical Professor, Department of Engineering and Science; Member, Faculty of Information Technology; Ph.D., (Swinburne University of Technology)
Index

Academic and Research Computing 16
Academic Calendar 4
Academic Credit 80
Academic Information and Regulations 67
Academic Load 71
Academic Prizes 90
Academic Standing 87
Accelerated Prelaw Program 236
Accelerated Programs 32
Accelerated STS-Law Program 275
Accreditation 10
Administration 573
Admissions 32
Advanced Materials 147
Advanced STS options 271
Advisers 71
Advising and Learning Assistance Center 18
Aeronautics 202, 209
Aerospace Engineering Curriculum 211
Air and Space Studies 407
Air Resources 146
Algorithm Design and Combinatorics 347
Alumni 10
Analytical Chemistry 337
Anthropology 272
Applied Geometry 366
Applied Mathematics curriculum 370
Applied Mechanics 209
Applied Mechanics/Mechanics of Materials 203
Applied Science 385
Applying for Financial Aid 39
Applying to Rensselaer 33
Approximation Theory 366
Astrobiology Minor for Chemistry Majors 344
Astronomy and Astrophysics 375
Athletics 27
Atmospheres of Titan and Jupiter 403
Auditing 69
Auralization 103
B.S. in Communication (Concentration in Web Design and Analysis) 262
Bachelor of Architecture (B.Arch.) Curriculum 108
Bachelor of Science in Building Sciences Curriculum 112
Bachelor’s Degree 73
Biochemical and Biomedical Engineering 146
Biochemistry 333
Biochemistry and Biophysical Chemistry 337
Biochemistry and Biophysics 329, 386
Biochemistry Minor for Chemistry Majors 343
Biochemistry Oriented Curriculum 342
Bioinformatics 348, 366
Bioinformatics and Molecular Biology 329, 390
Biology 329, 333
Biomaterials 142
Biomathematics 365
Biomechanics 143
Biomedical Engineering 136
Biomedical Instrumentation 142
Biophysics 333, 375
Biophysics Minor for Chemistry Majors 343
Brain and Behavior 249
Career Development Center 27
Cell and Tissue Biology 330
Cell and Tissue Engineering 137
Center for Advanced Interconnect Systems Technologies 22
Center for Automation Technologies 21
Center for Broadband Data Transport and Technology 23
Center for Composite Materials and Structures 227
Center for Image Processing Research 228
Center for Infrastructure and Transportation Studies 229
Center for Initiatives in Pre-College Education 19
Center for Integrated Electronics 21
Center for Microcontamination Control 22
Center for Multiphase Research 229
Center for Next Generation Video 230
Center for Power Electronics Systems 22
Center for Services Research and Education (CSRE) 165
Center for Subsurface Sensing and Imaging Systems 230
Center for Terahertz Research 393
Certificate in Human-Computer Interaction 266
Certificate in Multidisciplinary Environmental Studies 277
Chemical Engineering 145
Chemistry 336
Chemistry minor for Non-Chemistry majors 344
Cisco Networking Academy 353
Civil and Environmental Engineering 152
Civil Engineering Curriculum 157
Class Attendance and Examinations 82
Cognitive Engineering 244
Cognitive Science 243, 248
Cognitive Science Program 246
College Cost 39
Combustion Theory 366
Communication 264
Communication (Comm) Curriculum 260
<table>
<thead>
<tr>
<th>Subject</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication and Computers</td>
<td>257</td>
</tr>
<tr>
<td>Communications, Information, and Signal Processing</td>
<td>178</td>
</tr>
<tr>
<td>Community and Health Psychology</td>
<td>249</td>
</tr>
<tr>
<td>Complex Systems</td>
<td>366</td>
</tr>
<tr>
<td>Computational Bioengineering</td>
<td>137</td>
</tr>
<tr>
<td>Computational Chemistry and Spectroscopy</td>
<td>338</td>
</tr>
<tr>
<td>Computational Cognitive Modeling</td>
<td>244</td>
</tr>
<tr>
<td>Computational Geometry</td>
<td>348</td>
</tr>
<tr>
<td>Computational Mechanics (Civil)</td>
<td>154</td>
</tr>
<tr>
<td>Computer Hardware, Architecture, and Design</td>
<td>179</td>
</tr>
<tr>
<td>Computer Networking</td>
<td>348</td>
</tr>
<tr>
<td>Computer Networks</td>
<td>179</td>
</tr>
<tr>
<td>Computer Science</td>
<td>346, 352</td>
</tr>
<tr>
<td>Computer Science at Hartford</td>
<td>382</td>
</tr>
<tr>
<td>Computer Science Graduate Certificate Programs</td>
<td>383</td>
</tr>
<tr>
<td>Computer Vision</td>
<td>347</td>
</tr>
<tr>
<td>Computer Vision, Image Processing, and Digital Media</td>
<td>179</td>
</tr>
<tr>
<td>Computer-mediated design processes</td>
<td>103</td>
</tr>
<tr>
<td>Condensed Matter Physics</td>
<td>375</td>
</tr>
<tr>
<td>Control, Robotics, and Automation</td>
<td>180</td>
</tr>
<tr>
<td>Cooperative Education</td>
<td>63, 266</td>
</tr>
<tr>
<td>Core Program in Science</td>
<td>325</td>
</tr>
<tr>
<td>Database Systems</td>
<td>347</td>
</tr>
<tr>
<td>Dean of Students</td>
<td>25</td>
</tr>
<tr>
<td>Decision Sciences and Engineering Systems</td>
<td>164</td>
</tr>
<tr>
<td>Department of Engineering at Hartford</td>
<td>219</td>
</tr>
<tr>
<td>Design</td>
<td>209</td>
</tr>
<tr>
<td>Disabled Student Services</td>
<td>25</td>
</tr>
<tr>
<td>Discrete Event Simulation</td>
<td>346</td>
</tr>
<tr>
<td>Division of the Chief Information Officer</td>
<td>16</td>
</tr>
<tr>
<td>Doctor of Engineering</td>
<td>163</td>
</tr>
<tr>
<td>Doctoral Degree</td>
<td>77</td>
</tr>
<tr>
<td>Double Degrees</td>
<td>74</td>
</tr>
<tr>
<td>Dual Majors</td>
<td>74</td>
</tr>
<tr>
<td>Dynamical Systems</td>
<td>365</td>
</tr>
<tr>
<td>Early Admission</td>
<td>32</td>
</tr>
<tr>
<td>Early Decision</td>
<td>32</td>
</tr>
<tr>
<td>Earth and Environmental Sciences</td>
<td>356</td>
</tr>
<tr>
<td>Earthquake Engineering (Civ.)</td>
<td>153</td>
</tr>
<tr>
<td>Ecological Economics, Values, and Policy</td>
<td>274, 280</td>
</tr>
<tr>
<td>Economics</td>
<td>251</td>
</tr>
<tr>
<td>Education for Working Professionals</td>
<td>14</td>
</tr>
<tr>
<td>Educational Programs and Resources</td>
<td>11</td>
</tr>
<tr>
<td>Educational Research and Development in Physics</td>
<td>376</td>
</tr>
<tr>
<td>Electric Power and Power Electronics</td>
<td>181</td>
</tr>
<tr>
<td>Electric Power Engineering Curriculum</td>
<td>191</td>
</tr>
<tr>
<td>Electrical, Computer, and Systems Engineering</td>
<td>178</td>
</tr>
<tr>
<td>Electronic Arts</td>
<td>241</td>
</tr>
<tr>
<td>Electronic Arts Curriculum</td>
<td>238</td>
</tr>
<tr>
<td>Electronic enhancement of acoustical communication over large distances</td>
<td>103</td>
</tr>
<tr>
<td>Electronic Media, Arts, and Communication</td>
<td>278</td>
</tr>
<tr>
<td>Electronic Media, Arts, and Communication (EMAC) Curriculum</td>
<td>240, 263</td>
</tr>
<tr>
<td>Electronic tuning of room acoustic properties</td>
<td>103</td>
</tr>
<tr>
<td>Electronics Agile Manufacturing Research Institute (EAMRI)</td>
<td>165</td>
</tr>
<tr>
<td>Energy policy</td>
<td>104</td>
</tr>
<tr>
<td>Energy Systems</td>
<td>210</td>
</tr>
<tr>
<td>Energy Systems/Multiphase Phenomena and Heat Transfer</td>
<td>203</td>
</tr>
<tr>
<td>Engineering Core Curriculum</td>
<td>132</td>
</tr>
<tr>
<td>Engineering Physics Curriculum</td>
<td>215</td>
</tr>
<tr>
<td>Engineering Science</td>
<td>225</td>
</tr>
<tr>
<td>Ensembles</td>
<td>241</td>
</tr>
<tr>
<td>Entrance Tests</td>
<td>33</td>
</tr>
<tr>
<td>Environmental Engineering Curriculum</td>
<td>160</td>
</tr>
<tr>
<td>Environmental Health Physics and Radiation Dosimetry</td>
<td>203</td>
</tr>
<tr>
<td>Environmental Science</td>
<td>394</td>
</tr>
<tr>
<td>Environmental Science Concentration</td>
<td>362</td>
</tr>
<tr>
<td>Environmental Studies Program</td>
<td>283</td>
</tr>
<tr>
<td>Environmental Systems (Env.)</td>
<td>155</td>
</tr>
<tr>
<td>Exchange and Study-Abroad Programs</td>
<td>12</td>
</tr>
<tr>
<td>Executive Master of Business Administration (EMBA)</td>
<td>315</td>
</tr>
<tr>
<td>Faculty and Educational Innovations</td>
<td>8</td>
</tr>
<tr>
<td>Family Programs</td>
<td>26</td>
</tr>
<tr>
<td>Fees</td>
<td>64</td>
</tr>
<tr>
<td>Final Examinations</td>
<td>83</td>
</tr>
<tr>
<td>Financial Aid</td>
<td>39</td>
</tr>
<tr>
<td>Financial Technology</td>
<td>318</td>
</tr>
<tr>
<td>First Year Experience</td>
<td>26</td>
</tr>
<tr>
<td>First-Year Courses</td>
<td>13</td>
</tr>
<tr>
<td>Five Year B.S.-M.S.</td>
<td>276</td>
</tr>
<tr>
<td>Five-Year B.S.-M.S</td>
<td>276</td>
</tr>
<tr>
<td>Fluid Mechanics</td>
<td>145, 366</td>
</tr>
<tr>
<td>Focus Center at New York</td>
<td>22</td>
</tr>
<tr>
<td>Four-Year Affiliated College Engineering Program</td>
<td>35</td>
</tr>
<tr>
<td>French</td>
<td>264</td>
</tr>
<tr>
<td>Freshman Admission</td>
<td>32</td>
</tr>
<tr>
<td>Fusion Applications</td>
<td>216</td>
</tr>
<tr>
<td>Fusion Reactor Engineering</td>
<td>214</td>
</tr>
<tr>
<td>Gender, Science, and Technology</td>
<td>275</td>
</tr>
<tr>
<td>Generic Programming</td>
<td>347</td>
</tr>
<tr>
<td>Geochemistry and Petrology</td>
<td>357</td>
</tr>
<tr>
<td>Geophysics</td>
<td>357</td>
</tr>
<tr>
<td>Geotechnical Engineering (Civil)</td>
<td>154</td>
</tr>
<tr>
<td>German</td>
<td>264</td>
</tr>
<tr>
<td>Glasses and Ceramics</td>
<td>197</td>
</tr>
<tr>
<td>Global Management of Technology</td>
<td>319</td>
</tr>
<tr>
<td>Grading System</td>
<td>84</td>
</tr>
<tr>
<td>Graduate Admissions</td>
<td>37</td>
</tr>
<tr>
<td>Graduate Curricula and Courses of Instruction</td>
<td>74</td>
</tr>
<tr>
<td>Graduate Financial Aid</td>
<td>57</td>
</tr>
</tbody>
</table>
Graphics Certificate  266
Greek Affairs  25
H&SS Core Program  235
Health Physics  214
Heat Transfer  145
High Performance Data Mining and Computational Learning Systems  348
High-Performance Composite Materials  197
High-Temperature Kinetics  147
Higher Education Opportunity Program (HEOP)  43
History  273
Human and Machine Reasoning  244
Human Computer Interfaces  347
Human Factors  249
Hydrogeology and Environmental Geochemistry  357
Industrial and Management Engineering (IME) Curricula  171
Industrial and Organizational Psychology (Psychology)  244
Industrial/Organizational Psychology  250
Information Directory  6
Information Systems  165
Information Technology and Communication (IT/Comm) Curriculum  263
Information Technology—Arts Curriculum  240
Infrastructure Engineering (Civil)  154
Inorganic Chemistry and Solid-State Chemistry  337
Institute Diversity  19
Intelligent roadway systems  104
Interdepartmental Research  147
Interdisciplinary Programs and Research  277
Interdisciplinary Science  398
Interdisciplinary Studies Index  97
Interfacial Phenomena  146
International Services for Students and Scholars  25
International Students  36, 58
Internship Program  13
Interschool Minor in Energy  285
Interstellar Sources  402
Inverse Problems  364
IT Core Requirements  302
J.D.-MBA Program  315
Language, Literature, and Communication  256
Leave of Absence  89
Light and health  104
List of Graduate Fellowships  59
List of Undergraduate Scholarships  45
Literature  264
M.S. in Computer Science  354
M.S. in Computer Science Specializing in Computational Science and Engineering  354
Management Information Systems  318
Manufacturing Concentration  210
Manufacturing Systems Engineering (MSE) Curricula  173
Manufacturing/Design  203
Mass Transport  145
Master of Architecture I  116
Master of Building Science Degrees  119
Master of Business Administration  313
Master of Fine Arts in Electronic Arts  241
Master of Science in Building Conservation  120
Master of Science in Building Sciences (Concentration in Architectural Acoustics)  121
Master of Science in Building Sciences (Concentration in Workplace Design)  122
Master of Science in Lighting  123
Master of Science in Management  312
Master of Science in Philosophy  250
Master of Science in Psychology  251
Master of Science/Doctor of Philosophy  276
Master's Degree  75
Materials for Microelectronic Systems  197
Materials Science and Engineering  196
Mathematical Programming  165
Mathematical Programming and Operations Research  365
Mathematical Sciences  363
Mathematics Curriculum  369
Mathematics of Computation Curriculum  371
Mathematics of Operations Research Curriculum  371
MBA Concentrations  314
Measurement techniques for room acoustics  103
Mechanical Engineering Curriculum  208
Mechanical, Aerospace, and Nuclear Engineering  202
Media Design and Theory  257
Medical Determinations  89
Microbiology and Ecology  330
Microelectronics  380
Microelectronics Technology  181
Midyear Admission  32
Military Science  408
Minds and Machines Program  286
Minors  74
Molecular Simulations  146
Multidisciplinary Science  400
Multiphase Science and Technology  216
Music  240
Named Professorships  581
Naval Science  409
Navigating Rensselaer  26
New Product Development and Radical Innovation  318
New York Center for Studies on the Origins of Life  402
New York State Center for Polymer Synthesis  404
New York State Grant Programs  42
<table>
<thead>
<tr>
<th>Subject</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Engineering Curriculum</td>
<td>213</td>
</tr>
<tr>
<td>Nuclear Plant Operations and Management</td>
<td>214</td>
</tr>
<tr>
<td>Nuclear Science and Technology</td>
<td>203</td>
</tr>
<tr>
<td>Nuclear Thermal Hydraulics</td>
<td>214</td>
</tr>
<tr>
<td>Numerical Analysis and Scientific Computation</td>
<td>364</td>
</tr>
<tr>
<td>Office of Minority Student Affairs</td>
<td>25</td>
</tr>
<tr>
<td>Office of the Dean of Students</td>
<td>25</td>
</tr>
<tr>
<td>Operations Research and Statistics Curricula</td>
<td>175</td>
</tr>
<tr>
<td>Optical Physics</td>
<td>376</td>
</tr>
<tr>
<td>Oral and Maxillofacial Implants and Bone-Implant Interfaces</td>
<td>137</td>
</tr>
<tr>
<td>Organic Chemistry and Organometallic Chemistry</td>
<td>337</td>
</tr>
<tr>
<td>Orthopedic Biomechanics</td>
<td>137</td>
</tr>
<tr>
<td>Out-of-Classroom Experience</td>
<td>362</td>
</tr>
<tr>
<td>Particle Physics</td>
<td>376</td>
</tr>
<tr>
<td>Ph.D. in Computer Science</td>
<td>354</td>
</tr>
<tr>
<td>Ph.D. in Computer Science Specializing in Computational Science and Engineering</td>
<td>355</td>
</tr>
<tr>
<td>Ph.D. in Computer Science with a Specialization in Computational Molecular Biology</td>
<td>355</td>
</tr>
<tr>
<td>Philosophy</td>
<td>248</td>
</tr>
<tr>
<td>Philosophy Curriculum</td>
<td>246</td>
</tr>
<tr>
<td>Philosophy of Human Values and Society</td>
<td>249</td>
</tr>
<tr>
<td>Philosophy of Science and Logic</td>
<td>248</td>
</tr>
<tr>
<td>Photochemistry</td>
<td>338</td>
</tr>
<tr>
<td>Physician-Scientist Program</td>
<td>333</td>
</tr>
<tr>
<td>Physics, Applied Physics, and Astronomy</td>
<td>374</td>
</tr>
<tr>
<td>Plasma Engineering and Electromagnetics</td>
<td>183</td>
</tr>
<tr>
<td>Political Science</td>
<td>273</td>
</tr>
<tr>
<td>Pollutant Fate and Transport (Env.)</td>
<td>154</td>
</tr>
<tr>
<td>Polymer Chemistry and Materials Chemistry</td>
<td>338</td>
</tr>
<tr>
<td>Polymers</td>
<td>146</td>
</tr>
<tr>
<td>Portfolio</td>
<td>33</td>
</tr>
<tr>
<td>Prebiotic RNA Synthesis</td>
<td>403</td>
</tr>
<tr>
<td>Prehealth Programs</td>
<td>13</td>
</tr>
<tr>
<td>Prelaw Programs</td>
<td>13</td>
</tr>
<tr>
<td>Process Control and Design</td>
<td>147</td>
</tr>
<tr>
<td>Product Design and Innovation</td>
<td>125, 225, 288</td>
</tr>
<tr>
<td>Professional Masters Program in Ecological Economics, Values, and Policy</td>
<td>255</td>
</tr>
<tr>
<td>Program Adjustments</td>
<td>70</td>
</tr>
<tr>
<td>Program for Graduates of U.S. Navy Nuclear Power Training School</td>
<td>216</td>
</tr>
<tr>
<td>Psychology</td>
<td>248</td>
</tr>
<tr>
<td>Psychology Curriculum</td>
<td>246</td>
</tr>
<tr>
<td>Radiation Applications</td>
<td>216</td>
</tr>
<tr>
<td>Radiation Effects on Electronics</td>
<td>216</td>
</tr>
<tr>
<td>Reactions During Planet Formation</td>
<td>402</td>
</tr>
<tr>
<td>Reactor Engineering</td>
<td>214</td>
</tr>
<tr>
<td>Reactor Physics</td>
<td>213</td>
</tr>
<tr>
<td>Registration in Absentia</td>
<td>63</td>
</tr>
<tr>
<td>Religious Affairs</td>
<td>29</td>
</tr>
<tr>
<td>Rensselaer Dining Services</td>
<td>30</td>
</tr>
<tr>
<td>Rensselaer in Brief</td>
<td>7</td>
</tr>
<tr>
<td>Rensselaer Nanotechnology Center</td>
<td>23</td>
</tr>
<tr>
<td>Rensselaer Statistical Consulting Center (RSCC)</td>
<td>166</td>
</tr>
<tr>
<td>Research</td>
<td>8</td>
</tr>
<tr>
<td>Research Facilities and Equipment</td>
<td>339</td>
</tr>
<tr>
<td>Research Related Facilities</td>
<td>147</td>
</tr>
<tr>
<td>Research Resources and Centers</td>
<td>21</td>
</tr>
<tr>
<td>Residence Life</td>
<td>30</td>
</tr>
<tr>
<td>Rhetoric, Culture, and Communication Technology</td>
<td>257</td>
</tr>
<tr>
<td>Robotics</td>
<td>348</td>
</tr>
<tr>
<td>ROTC Financial Aid Programs</td>
<td>42</td>
</tr>
<tr>
<td>School of Architecture</td>
<td>101</td>
</tr>
<tr>
<td>School of Science</td>
<td>323</td>
</tr>
<tr>
<td>Science</td>
<td>352</td>
</tr>
<tr>
<td>Science and Technology Studies</td>
<td>267</td>
</tr>
<tr>
<td>Science, Technology, and Society</td>
<td>272</td>
</tr>
<tr>
<td>Scientific Computation and Numerical Analysis</td>
<td>346</td>
</tr>
<tr>
<td>Scientific Computation Research Center</td>
<td>24</td>
</tr>
<tr>
<td>Search for Catalytic RNA Sequences</td>
<td>403</td>
</tr>
<tr>
<td>Senior “F” Examination Rule</td>
<td>83</td>
</tr>
<tr>
<td>Separation Processes</td>
<td>146</td>
</tr>
<tr>
<td>Service Systems</td>
<td>164</td>
</tr>
<tr>
<td>Seven-year Accelerated Physician-Scientist Program</td>
<td>335</td>
</tr>
<tr>
<td>Shock Processing of Prebiotic Materials</td>
<td>402</td>
</tr>
<tr>
<td>Simulation, data, and design</td>
<td>104</td>
</tr>
<tr>
<td>Sino-U.S. Programs</td>
<td>315</td>
</tr>
<tr>
<td>Site Remediation and Bioremediation (Environmental)</td>
<td>155</td>
</tr>
<tr>
<td>Sociology</td>
<td>274</td>
</tr>
<tr>
<td>Solid state lighting</td>
<td>104</td>
</tr>
<tr>
<td>Space Technology</td>
<td>204, 210</td>
</tr>
<tr>
<td>Special Opportunities in Environmental Science</td>
<td>397</td>
</tr>
<tr>
<td>Standardized Test Requirements</td>
<td>33</td>
</tr>
<tr>
<td>Statistics and Applied Probability</td>
<td>165</td>
</tr>
<tr>
<td>Structural Engineering (Civil)</td>
<td>154</td>
</tr>
<tr>
<td>STS Methods/Statistics Option</td>
<td>271</td>
</tr>
<tr>
<td>Student Conduct</td>
<td>26</td>
</tr>
<tr>
<td>Student Health Service</td>
<td>31</td>
</tr>
<tr>
<td>Student Life</td>
<td>25</td>
</tr>
<tr>
<td>Student Orientation</td>
<td>26</td>
</tr>
<tr>
<td>Student Records and Financial Services</td>
<td>31</td>
</tr>
<tr>
<td>Student Rights and Responsibilities</td>
<td>44</td>
</tr>
<tr>
<td>Students</td>
<td>7</td>
</tr>
<tr>
<td>Studio Arts</td>
<td>240</td>
</tr>
<tr>
<td>Study-Review Period</td>
<td>83</td>
</tr>
<tr>
<td>Summer Session at Albany Medical College</td>
<td>335</td>
</tr>
<tr>
<td>Credit hours</td>
<td>335</td>
</tr>
<tr>
<td>Surface Science</td>
<td>338</td>
</tr>
<tr>
<td>Synthetic sensing and synthetic environments</td>
<td>103</td>
</tr>
<tr>
<td>Technological Entrepreneurship</td>
<td>318</td>
</tr>
<tr>
<td>The Academy of Electronic Media</td>
<td>24</td>
</tr>
</tbody>
</table>
INDEX

The Anderson Center for Innovation in Undergraduate Education 18
The Archer Center for Student Leadership Development 29
The Arts 237
The Darrin Fresh Water Institute 401
The DMM Sequence 314
The Faculty 582
The Impact History of the Primitive Earth 403
The Lally Graduate Programs 311
The Oxidation State of the Earth's Crust and Mantle 403
The Rensselaer Research Libraries 17
The Rensselaer Union 29
The RNA World 403
Thermodynamics 145
Thesis, Projects, and Professional Projects 77
Thioacids as Phosphorylating Reagents 403
Transferring Credit Towards the Science Core 326
Transportation Engineering (Civ.) 154
Tuition and Fees 62
Tuition Assistance Program (TAP) 43
Tuition Refunds for Official Withdrawals 63
Two-Year College Affiliated Program 34
Undergraduate Admissions 32
Undergraduate Financial Aid 39
Undergraduate Transfer Admissions/Special Programs 34
Veterans’ Benefits 58
Visiting Artists Series 241
Waste Treatment (Environmental) 154
Water Treatment (Env.) 154
Wave Propagation 365
Why Not Change the World? The Rensselaer Plan 10
Williams and Harvey Mudd Exchanges 69
Withdrawal from Rensselaer 88
Worldwide Computing 347