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ACADEMIC CALENDAR
1983-1984

FALL
Monday, August 29, 1983 -- Friday, September 2, 1983 -- Registration
Monday, September 5, 1983 -- Labor Day -- Holiday
Thursday, September 8, 1983 -- Classes begin
Thursday, Friday, November 24, 25, 1983 -- Thanksgiving Recess
Saturday, December 10, 1983 -- Classes end
Monday, Tuesday, December 12, 13, 1983 -- Reading days
Wednesday, December 14, 1983 -- Thursday, December 22, 1983 -- Final exams

RECESS
Friday, December 23, 1983 -- Sunday, January 1, 1984

INTERSESSION
Wednesday, January 4, 1984 -- Friday, January 13, 1984

SPRING
Monday, January 16, 1984 -- Friday, January 20, 1984 -- Registration
Thursday, January 26, 1984 -- Classes begin
Monday, April 16, 1984 -- Saturday, April 21, 1984 -- Recess
Wednesday, May 2, 1984 -- Classes end
Thursday, Friday, May 3, 4, 1984 -- Reading days
Monday, May 7, 1984 -- Tuesday, May 12, 1984 -- Final exams
Thursday, May 31, 1984 -- Commencement

INTERSESSION
Wednesday, May 16, 1984 -- Tuesday, May 29, 1984

SUMMER
Tuesday, Wednesday, May 29, 30, 1984 -- Registration
Monday, June 4, 1984 -- Classes begin
Friday, June 29, 1984 -- Wednesday classes meet
Wednesday, July 4, 1984 -- No classes
Friday, August 24, 1984 -- Classes end

1984-1985

FALL
Monday, August 27, 1984 -- Friday, August 31, 1984 -- Registration
Monday, September 3, 1984 -- Labor Day -- Holiday
Thursday, September 6, 1984 -- Classes begin
Thursday, Friday, November 22, 23, 1984 -- Thanksgiving Recess
Saturday, December 8, 1984 -- Classes end
Monday, December 10, 1984 -- Reading days
Thursday, December 13, 1984 -- Friday, December 21, 1984 -- Final exams

RECESS
Monday, December 24, 1984 -- Tuesday, January 1, 1985

INTERSESSION
Wednesday, January 2, 1985 -- Tuesday, January 15, 1985

SPRING
Wednesday, January 16, 1985 -- Tuesday, January 22, 1985 -- Registration
Friday, January 25, 1985 -- Classes begin
Friday, April 5, 1985 -- Friday, April 12, 1985 -- Recess
Friday, May 3, 1985 -- Classes end
Monday, Tuesday, May 6, 7, 1985 -- Reading days
Wednesday, May 8, 1985 -- Thursday, May 16, 1985 -- Final exams
Commencement -- Date to be announced

INTERSESSION
Friday, May 17, 1985 -- Thursday, May 30, 1985

SUMMER
Friday, May 31, 1985 -- Monday, June 3, 1985 -- Registration
Wednesday, June 5, 1985 -- Classes begin
Thursday, July 4, 1985 -- No classes
Friday, July 12, 1985 -- Thursday classes meet
Tuesday, August 27, 1985 -- Classes end

1985-1986

FALL
Tuesday, Wednesday, September 3, 4, 1985 -- Registration
Monday, September 9, 1985 -- Classes begin
Wednesday, September 25, 1985 -- No classes (Yom Kippur)
Thursday, Friday, November 28, 29, 1985 -- Thanksgiving Recess
Monday, December 9, 1985 -- Thursday classes meet
Tuesday, December 10, 1985 -- Friday classes meet
Wednesday, December 11, 1985 -- Classes end
Thursday, December 12, 1985 -- Reading days
Friday, December 13, 1985 -- Friday, December 20, 1985 -- Final exams

RECESS
Monday, December 23, 1985 -- Tuesday, January 1, 1986

INTERSESSION
Thursday, January 2 -- Wednesday, January 15, 1986

SPRING
Thursday, Friday, January 16, 17, 1986 -- Registration
Wednesday, January 22, 1986 -- Classes begin
Friday, March 26 -- Friday, April 4, 1986 -- Recess
Wednesday, April 30, 1986 -- Friday classes meet
Wednesday, April 30, 1986 -- Classes end
Thursday, Friday, May 1, 2, 1986 -- Reading days
Monday, May 5 -- Tuesday, May 13, 1986 -- Final exams
Commencement -- Date to be announced

INTERSESSION
Wednesday, May 14 -- Tuesday, May 27, 1986

SUMMER
Wednesday, Thursday, May 28, 29, 1986 -- Registration
Tuesday, June 3, 1986 -- Classes begin
Friday, July 4, 1986 -- No classes
Monday, August 25, 1986 -- Classes end

*Dates and times of registration at individual campuses are published in semester course bulletins.
Polytechnic Institute of New York is the largest, most extensive technological institution in Greater New York. The second oldest technological university in the nation, Polytechnic was founded in 1854. It was at Polytechnic that pioneering research was conducted in such important fields as X-ray scatterings, radar, microwaves, plastics and re-entry vehicles for the space program. Graduates have made important breakthroughs in such research areas as television broadcast technology, nuclear fission, bridge construction and dental anesthetics.

In 1973 Polytechnic absorbed New York University’s School of Engineering and Science. Today, Polytechnic has campuses in Brooklyn and Farmingdale (Long Island) and a graduate center in White Plains (Westchester).

A coeducational, independent university, Polytechnic has an enrollment of nearly 5,000 graduate and undergraduate students. The engineering enrollment (bachelor’s, master’s and doctoral) is first in New York State and one of the largest in the nation. About 13 percent of the student body are women.

The undergraduate program includes courses leading to 18 degrees in engineering, science and the humanities. The graduate program in science, engineering and management offers 34 master of science degrees; 11 engineering degrees, and 24 Ph.D. degrees.

Traditionally, Polytechnic has been strong in chemistry, physics, mathematics and the major engineering disciplines—chemical, electrical, civil, mechanical and aerospace. It also has a number of specialized departments and programs, such as computer science, metallurgy, nuclear engineering, transportation engineering and military science.

Many of Polytechnic’s 230 faculty members are nationally and internationally recognized for their achievements as teachers, scholars and researchers. The Polytechnic faculty conducts over $5 million of research annually.

Conferring more than 400 baccalaureate degrees and more than 500 graduate degrees annually, Polytechnic now has 26,500 alumni around the world. In 1982, more than 95 percent of Polytechnic graduates who sought employment found positions in their fields.

HISTORY

The two engineering colleges that merged in 1973 to become Polytechnic Institute of New York have roots in New York City going back to the same year. In 1854, the Brooklyn Collegiate and Polytechnic Institute received its charter from the New York State Board of Regents. That same year New York University established its school of civil engineering and architecture. Both schools began instruction in 1855. And in 1973, the inheritors of these traditions joined forces to form a single institution.

In 1869 the Board of Regents authorized Polytechnic’s collegiate department to confer bachelor of science and bachelor of arts degrees, the first of which were awarded in 1871. Polytechnic Institute of Brooklyn, the name given to the school in 1889, offered master of science degrees as early as 1901. The graduate program was extended to the evening session in the 1920’s and the first Ph.D. degrees were given in 1935. The first engineer degree—between the master’s and the Ph.D. on the academic scale—was awarded in 1970.

Dr. George Bugliarello, the first president of the merged institution, assumed office in 1973. Before his election as president of Polytechnic Institute of New York, Dr. Bugliarello had been Dean of Engineering at the University of Illinois at Chicago Circle, where he also served as Professor of Biotechnology and Civil Engineering. He received the degree of Dr. Ing. (summa cum laude) from the University of Padua, and the Sc.D. degree from the Massachusetts Institute of Technology in 1959. His books and research publications are concerned with bioengineering, fluid mechanics, computer languages and social technology.

PURPOSE

At Polytechnic, the scientific orientation of the curricula begins with a common freshman year. Here, new approaches in the teaching of mathematics, chemistry and physics provide the solid basis for the specialization that comes in varying degrees during the following three years.

No longer is it possible to isolate science and engineering, to teach engineering design primarily as an "art." Nevertheless, fundamental differences in attitude distinguish the professions of science and engineering.

Scientific exploration is directed toward the accumulation of factual knowledge and the understanding of the basic forces and phenomena of the world. Engineering, on the other hand, has been defined by the Accreditation Board for Engineering and Technology as "the profession in
which a knowledge of the mathematical and natural sciences gained by study, experience, and practice is applied with judgment to develop ways to utilize economically the materials and forces of nature for the progressive well-being of mankind."

The humanities and social sciences are well established at Polytechnic, partly because of the original nature of the Institute. A minimum of one-sixth of the total course work is devoted to literature, economics, history and modern languages. This area is specifically designed so the scientist and engineer will be prepared for the broader responsibilities that will come with career advancement. In addition, those who wish to do so may acquire a bachelor's degree in either humanities (with concentration in humanistic studies or communications) or in social sciences (history, economics or behavioral science).

The evening classes at Polytechnic allow the student unusual latitude in adjusting a program to the realities of outside employment.

Polytechnic is accredited by the Middle States Association, the New York State Board of Regents and various professional organizations. While the undergraduate chemistry program is approved by the American Chemical Society, the Accreditation Board for Engineering and Technology accredits the undergraduate programs in aerospace, chemical, civil, electrical, industrial, mechanical and metallurgical engineering.

Although most undergraduate students live in New York City and surrounding communities, there are many who come from outside the state. The graduate programs draw students from all over the world, another indication of Polytechnic's reputation in engineering and science.

FACULTY

The faculty originates, organizes and approves all curricula taught at Polytechnic. Faculty members meet with students in lectures, seminars, laboratories and on field trips; they advise and examine students to determine established standards of achievement.

The faculty is also involved in non-teaching activities, conducting research. Many are also authors of textbooks used throughout the United States. Polytechnic students, therefore, have daily contact with recognized professionals who are making significant, continuing contributions to their professions.

ALUMNI

The Polytechnic Alumni Association promotes the welfare of Polytechnic and the individual alumna and alumnus. As the needs and interests of the alumni change, the responsibilities and objectives of the Alumni Association also change. It is primarily a service organization for all alumni, particularly in the area of continuing education and professional job placement and new student recruitment. While fellowship is a very important aspect of the Association's activities, it is a by-product of the service programs for alumni.

The Alumni Association sponsors the annual Freshman Round-up where incoming students meet recent graduates. Panel discussions, led by career alumni, highlight two yearly career conferences at which students meet with alumni to discuss problems they may face when they enter the business world.

The Alumni Association has established a Student Auxiliary Committee within the structure of the Association. This all-student committee works closely and meets regularly with the Association's Board of Directors to promote liaison between alumni and students, to develop programs whereby student/alumni mutual interests may be more fully realized, and to acquaint students with benefits to be derived by their later participation as alumni in the Association's services and programs. Alumni residing outside the New York City area have formed Poly Groups, providing opportunities for informal gatherings. Whenever they meet, they represent Polytechnic to the community.

Periodically, the Alumni Association Office, located at Polytechnic, publishes a roster showing the location and occupation of all known alumni. Cable, the Association's newspaper, is published four times yearly to provide alumni with recent information concerning the activities of the Association and Polytechnic.

Scholarships are provided annually by the Association for students outstanding in student leadership and athletics. Special awards are presented to the student who is most proficient in each Polytechnic sport, in military service and in student government.

The services of the Association are available to all through the Alumni Office and its director. Membership in the Association is automatic upon graduation, with classes represented on the Board of Directors through their elected representatives.
CAMPUSES
AND FACILITIES

THE CAMPUSES

Brooklyn Campus
Polytechnic's Brooklyn campus is located at 333 Jay Street, downtown Brooklyn. This area is criss-crossed by public transportation lines and is accessible from any part of New York City, Long Island, New Jersey and Connecticut.

Because of Polytechnic's central location, its students have at their disposal the vast cultural, political and technological assets of the metropolis. In effect, Greater New York is Polytechnic's campus.

Rogers Hall, named after Harry Stanley Rogers, Polytechnic's fifth president, is the main building. It houses faculty and administrative offices, classrooms, laboratories and the main library. The Administration Building contains administrative and faculty offices, the Office of Dean of Student Life and the Admissions, Bursar's and Student Records Offices.

William H. Nichols Hall, Johnson and Bridge Streets, houses the placement office, research activities, laboratories, offices and classrooms.

The Student Center, located at 311 Bridge Street, housing a cafeteria, lounges, game room and student offices, is the focal point for student co-curricular activities. The building is open Monday to Friday, with facilities available to student groups at other times by reservation. Also in the Student Center are the Polytechnic student-run radio station, yearbook, newspaper and student government offices. During the regular academic year, the Center is open from 8:45 AM to 6 PM Monday through Thursday; from 8:45 AM to 5 PM on Friday. Café hours are from 9:30 AM to 5:30 PM, Monday through Thursday; 9:30 AM to 3 PM on Friday.

Long Island Campus
The Long Island campus, Route 110, Farmingdale, was opened in the fall of 1961 for graduate study and research in response to the educational needs of Nassau and Suffolk Counties. Located on 25 acres of land a half-mile east of the Nassau-Suffolk border, the campus is bordered by Republic Airport and is situated near scores of major Long Island high-technology industries.

The Main Administration Building contains classrooms, a cafeteria, an auditorium, conference and meeting rooms, a student lounge, faculty and administration offices and laboratories for research. Areas of research include electromagnetics, wave propagation, space-science radiophysics, quantum electronics, modern optics, laser techniques, high-frequency solid-state phenomena and devices, microwaves, antennas and ultrasonics. The building also includes a science-engineering library with 35,000 volumes of periodicals and reference works specifically selected to support the courses and research conducted at the campus.

Preston R. Bassett Research Laboratory contains laboratories for research in gas dynamics, aerophysics, plasma physics and ultrahigh power microwaves, as well as teaching laboratories.

Grumman Hall, the student center, houses a lounge, the rathskeller, a game room, a bookstore and the student organization offices. During the regular academic year, this student facility is open from 8 AM to 9 PM Monday through Thursday; 8 AM to 5 PM on Friday. The cafeteria — in the main building — is open for the same hours.

The Student Residence Hall, an apartment-style dormitory, with kitchen facilities, for single students, accommodates 50 students, both undergraduate and graduate.

The Athletic Facility is the newest addition to the Long Island campus.

Westchester Graduate Center
In response to the educational needs of graduate scientists, engineers, and managers employed at many high-technology companies in the Lower Hudson Valley and Southern Connecticut, Polytechnic has established late afternoon and evening graduate programs at White Plains. It offers graduate degree programs in civil engineering, computer science, economic systems, electrical engineering and management. Other graduate courses offered include chemistry, energy policy, environmental engineering, industrial engineering and metallurgical engineering.

The Westchester Graduate Center, 456 North Street, White Plains, includes classrooms, a computer terminal room and the Richard Laster Library Lounge.
FACILITIES

LIBRARIES

Acquiring, storing, retrieving and making available recorded knowledge in all its forms and vast quantity is the major function of the Polytechnic libraries. Its services are geared to assist all students in coping with our increasingly complex information/data environment.

Spicer Memorial Library has two public service sections: the Circulation Department, located on the first floor of Rogers Hall, and the Reference Departments, located on the second floor of the Administration Building. Spicer Library is the center of Polytechnic's library system and contains one of the best collections of technical and scientific literature in the metropolitan area. The library also includes materials for research in the humanities, the social sciences and management. It contains more than 270,000 volumes, subscribes to 1,200 periodicals, has a half-million microforms and maintains a government document collection. Monday to Thursday 9 AM to 8:30 PM, Friday 9 AM to 5 PM, Saturday 1 PM to 5 PM.

The Long Island campus at Farmingdale is served by a library supporting its undergraduate, graduate and research programs. Monday to Thursday 9 AM to 9 PM, Friday 9 AM to 5 PM.

The Richard Laster Library Lounge was dedicated at the Westchester Graduate Center in the spring of 1979. Its collection reflects the areas of academic concentration at Westchester. Monday to Thursday 9 AM to 9 PM, Friday 10 AM to 2 PM.

A highly trained, experienced staff of librarians and information specialists offers a wide range of reference services: the most significant is individual counseling, and referral. Through the library's participation in a number of cooperative arrangements and regional networks, access is available to the vast library resources of the metropolitan area. Students are encouraged to visit the reference desk frequently to discuss their information needs. Other services are: library orientation for freshmen, classroom instruction on library use as requested by faculty, interlibrary loan, and, as an added benefit to the researcher, the library offers online literature searches covering all disciplines.

COMPUTER CENTER

Polytechnic maintains a Computer Center responsive to educational and administrative needs. It is available to faculty and students for use in course work and research.

On the Brooklyn campus, Rogers Hall contains the Institute's main computer facility, which houses an IBM 4341 and a DEC 1170 which can be accessed through terminals throughout the Institute, including the Long Island and Westchester campuses. The Center also contains an IBM 4341 mainframe, dedicated to computer-aided graphics and design. This computer supports similar activities via high-speed terminal links at the Long Island and Westchester campuses. The Brooklyn campus also has a personal computer laboratory.

The Long Island Center is equipped with its own DEC 1160, Harris 800, and Gould 32/6750 computers, as well as an APOLLO 4-node computer network. In addition, the Long Island Center has access to all of the computer facilities, including the computer-aided design and manufacturing system housed at the Brooklyn campus.

Beginning in the fall, 1983, all entering freshmen at both campuses will receive personal computers which they will use throughout their undergraduate course of study at the Institute.

RESEARCH CENTERS

CENTER FOR ADVANCED TECHNOLOGY IN TELECOMMUNICATIONS

The State of New York has designated Polytechnic as the New York Center for Advanced Technology in Telecommunications. This designation means that state funds will be allocated for Polytechnic research in telecommunications and to provide educational support for New York based corporations within telecommunications and related fields, such as computer science. Polytechnic is the only center in the State of New York to receive a designation in telecommunications. The Center and its related activities further strengthens Polytechnic's strong academic position in electrical engineering and computer science.

Seven research laboratories will be contained in the Center for Advanced Technology in Telecommunications. They are:

- Network Design
- Local Area Network
- Software Engineering
- Device Testing/Integrated Optics
- Imaging Communications
- Office of the Future
- Telecommunications Technology Management

Faculty members at Polytechnic have conducted research in various fields related to telecommunications. Organization of the laboratories within the Center will allow greater concentration of research and financial support from New York State. This activity will provide greater opportunity for students to learn about the academic disciplines related to telecommunications and computer science.

CENTER FOR DIGITAL SYSTEMS

The Center for Digital Systems was established on the Long Island campus in 1982, with a founding grant from the Fairchild Republic Corporation. The goal of the Center is to promote close cooperation in educational and research programs between Polytechnic and industry in areas relating to the development of digital systems technology.

Specific topics for study within the scope of the Center include: fault tolerant system architectures to achieve enhanced system reliability; high speed data base technology and fiber optic communications, with special emphasis on the use of these media in avionic systems; computer-aided design of VLSI and VHSIC components; advanced techniques for the integration and automatic
testing of complex digital systems, software engineering and simulation tools for the development and evaluation of digital system software.

The Center's activities are carried out by faculty, staff and graduate students from the Electrical Engineering and Computer Science Department. These projects are supported by government and industry with a major commitment to cooperate with industry on both short- and long-term projects, using capabilities maintained within the Center for Digital Systems.

INSTITUTE OF IMAGING SCIENCES

Imaging Sciences concerns all aspects of information in the form of pictures. The Institute of Imaging Sciences (IIS), founded with a private gift of $1 million, involves 25 faculty in three major areas—image processing, optics and devices, and photoactive materials. The approach is strongly interdisciplinary, with participation from electrical engineering, computer science, chemistry and physics.

IIS conducts research and offers educational programs in these areas, in close cooperation with industry. Programs are guided by a Technical Advisory Committee of industrial representatives. In addition to imaging research projects and courses, IIS publishes a newsletter, Imaging Quarterly, and holds an annual research review.

MICROWAVE RESEARCH INSTITUTE

The internationally renowned Microwave Research Institute (MRI) was founded at Polytechnic in 1943 in response to wartime needs for new types of microwave components for radar applications. After World War II, the Institute continued to achieve stature under the leadership of its founder and first director, Dr. Ernst Weber. In collaboration with the academic departments, MRI has helped educate more microwave engineers than any other institute in the country.

In recent years, MRI has broadened the scope of its research activities to include the full range of topics encompassed by the broad field of electronics. These activities include such seemingly diverse subjects as lasers, plasma physics, space radio-physics, x-rays, acoustics, wave propagation, microwave antennas, solid state materials, communication theory, control systems and high image processing.

Through MRI, Polytechnic participates in the Joint Services Electronics Program, a basic research program sponsored by the federal government. This distinguished program involves only a few specially selected universities, and it places Polytechnic in the company of such schools as Harvard, M.I.T. and Stanford.

POLYMER RESEARCH INSTITUTE

The Polymer Research Institute, a division of the Chemistry Department, is the oldest academic center of polymer investigations in the United States and enjoys a world-wide reputation. It was founded in 1940 by Dr. Herman F. Mark, who continues as dean emeritus of Polytechnic.

At present, six members of the Chemistry Department are engaged in teaching courses that deal with macro-molecules and supervising research in that field. In addition, the "Polymer Science and Engineering" program is conducted in cooperation with three members of the Chemical Engineering Department specializing in polymer technology.

As a consequence of the long tradition in the teaching of polymer science at Polytechnic, we may count among our graduates a large proportion of both academic and industrial scientists active in that field.

Otto Vogl was appointed in January, 1983 as the Herman F. Mark Professor of Polymer Science. The appointment of Professor Vogl to this distinguished post reaffirms a continuing commitment by Polytechnic to the Polymer Research Institute, which serves as a focal point for unifying interdisciplinary activities in chemistry, physics and technology associated with polymer science and engineering.

METROTECH

Polytechnic is the developer of a $400,000,000 high technology center known as MetroTech. Working with New York City and its Public Development Corporation, 17 acres of redeveloped land surrounding Polytechnic's Brooklyn campus will be turned into a high technology complex dedicated to close industry-academic cooperation in research and development.

MetroTech will include a Technology and Science Library, linked electronically to worldwide data sources. The library will also serve Polytechnic students, providing access to technological data and information not available elsewhere. Because the library will also be a major source of information for technologically based industries, students will be able to keep pace with the most advanced information utilized by industries which provide employment opportunities for graduates of Polytechnic.

As much as one-and-a-half-million square feet of office, lab and computer space will be made available to the private sector within the MetroTech complex. Corporations will design this space to meet their needs. Industrial and educational objectives will be met through a close working relationship between Polytechnic and corporate technical and management personnel within MetroTech. Students will have the opportunity to observe at close range the application of lessons learned in the classroom as they are applied within high-tech corporations.

Another component of MetroTech will be a hotel/conference center. This facility will make it possible to bring scientists, engineers and managers to conferences of interest to both private sector and academic groups. Such conferences and meetings will provide additional opportunities for students to interact with professionals within technical fields of their interest.

MetroTech will also contain the Center for Advanced Technology in Telecommunications.
TRANSPORTATION TRAINING AND RESEARCH CENTER

The Transportation Training and Research Center (TIRC) is concerned with applied research, basic research and training in transportation and related areas. The Polytechnic established TIRC in 1975 to identify its mission in transportation and related areas, and to encourage the interdisciplinary and interdepartmental efforts so necessary in this field.

The TIRC is Polytechnic's statement that:
• It is committed to such interdisciplinary research, removed from internal departmental concerns;
• It will provide the research sponsor with the experience, continuity and achievement record of depth and substance in a single identified internal entity, to the benefit of that sponsor;
• It will provide the resources to accomplish the obligated work, in the clearly-defined administration of TIRC.

The message is thus performance, responsibility and experience.

The TIRC experience includes:
• Transportation Policy Studies
• Traffic Operations and Capacity
• Environmental Impact and Noise
• Transportation Planning and Management
• Transportation Finance

It is proud of its recent work on transportation energy, urban goods, travel training of the retarded, implications of fully accessible systems, minority faculty workshops, short courses and other activities. It has undertaken work for most relevant federal administrations, and for state and local government.

FIRE RESEARCH CENTER

The Fire Research Center was established in recognition of the national need to direct the efforts of the scientific and technological communities to the complex issues of unwanted fire. The Center is located in the former Brooklyn Fire Headquarters, a landmark building on Jay Street, just south of Rogers Hall.

The Center draws on the expertise of civil engineering staff experienced in building design and construction and urban and fire protection engineering, as well as research faculty from other relevant disciplines, including low velocity aerodynamics, the behavior of polymeric materials and the behavioral sciences.

Principal focus of research is on the study of the performance of structures exposed to fire and to those aspects of fire phenomena dealing with ignition, growth and extension, and the control of products of combustion. Much of this work is directed toward the establishment of criteria and standards for use in building and fire codes.

Over the past decade, research assignments have included conducting full scale fire tests; writing new fire safety codes for high-rise buildings under sponsorship of the New York City Fire and Building Departments; the study of fire in high-risk residential buildings and the design of low-cost fire protection measures for these structures, for the Fire Department and the Department of Housing Preservation and Development; fire prevention in urban communities for the U.S. Fire Administration; and a wide range of fire-related projects for the design professions.

Current activities of the Center include the development of a state-of-the-art laboratory for the investigation of fire and the design of a computer-based fire simulation and training system.

The Center sponsors and conducts seminars, conferences and short courses of interest to the various components of the fire safety community, including the fire services, fire protection engineers, the design professions and insurance industry. Both undergraduate and graduate students are encouraged to participate in the Center's projects and programs.
UNDERGRADUATE PROGRAMS

Students may work toward a bachelor's degree either in four years of full-time study in the day session or in a longer period of part-time study. The number of credits full-time students take each semester depends on the curriculum and ranges from 12 to 20.

Students are admitted as freshmen in September and January or February. Day students entering in September follow normal curricula outlined for fall and spring semesters. Those entering in January or February follow a program determined in conjunction with their advisers.

Programs leading to some baccalaureate degrees may be pursued completely or largely through evening classes. In addition, individual courses or groups of courses may be pursued independently by qualified students who wish to concentrate upon particular subjects or who want to achieve competence in a limited branch of engineering, sciences, management, the humanities or the social sciences.

GRADUATE PROGRAMS

Graduate study at Polytechnic is open on a full-time and part-time basis to persons who hold bachelor's degrees from accredited institutions. Students may work toward graduate degrees—master of science, engineer, or doctor of philosophy—or take courses for personal or professional reasons. Not all graduate programs or courses are offered at all campuses; students are referred to the program descriptions under the various departments and to the Course Bulletin, available at the Office of Student Records.

SUMMER COURSES

Polytechnic offers a wide variety of full-credit summer courses for both day and evening, undergraduate and graduate students during the summer months. The schedule of summer courses may be obtained from the Office of Student Records.

Civil engineering undergraduate students attend surveying camp for two weeks during the summer preceding their sophomore year.

Students enrolled in the advanced course of the Reserve Officers Training Corps attend an active Army camp for six weeks during the summer preceding their senior year. Also during the summer the military science department offers Compression Programs to allow for advanced placement within the Reserve Officers Training Corps.

COOPERATIVE EDUCATION PROGRAM

The Cooperative Education Program is an alternative to the standard four-year educational program. It combines college studies with practical working experience in industry, government and public service. The five-year Cooperative Education Program offers experience at a professional level interspersed with a strong academic curriculum.

The Cooperative Education Program is available to undergraduate students who have:
1. Completed at least 30 credits of academic work with no course deficiencies
2. Maintained at least a 2.5 cumulative average
3. Successfully completed Cooperative Education Seminars CP 101-102

Freshmen, therefore, would be eligible for their first work experience during the summer following the completion of their first academic year. Graduate students and transfer students are eligible usually after completion of one semester.

Students who apply and are accepted to the program will start interviewing with participating co-op companies during the semester prior to their first work experience. The Cooperative Education Office will be responsible for setting up the interviews. In most cases the company interview will determine whether or not the student is hired as a co-op employee. Once "on the job" the co-op student employee will be paid a salary and usually receives company benefits. In all cases the students will be given the opportunity to work at tasks directly related to their career goals.
## Certificate Programs*

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<th>HEGIS CODE</th>
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*All programs offered at Brooklyn campus, except Polymeric Materials, offered at Farmingdale and Westchester campuses.*
DEGREES OFFERED AT POLYTECHNIC

Polytechnic's programs lead to the Bachelor of Science, Master of Science, Engineer and Doctor of Philosophy degrees. For convenience and clarity the following list of degrees offered includes not only those with departmental identifications but also the topics of major options within degrees. For more information on degree titles, descriptions and requirements, please see departmental listings.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Brooklyn Campus</th>
<th>Farmingdale Campus</th>
<th>Westchester Campus</th>
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<tbody>
<tr>
<td>Aerospace Engineering (0902)</td>
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<tr>
<td>Aeronautics &amp; Astronautics (0902)</td>
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<tr>
<td>Applied Mathematics (1703)</td>
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<tr>
<td>Applied Mechanics (0921)</td>
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<tr>
<td>Applied Statistics (1702)</td>
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<tr>
<td>Bioengineering (0905)</td>
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<tr>
<td>Chemical Engineering (0906)</td>
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<tr>
<td>Chemical Physics (1902)</td>
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<tr>
<td>Chemistry (1905)</td>
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<tr>
<td>Civil Engineering (0908)</td>
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<tr>
<td>Computer Science (0901)</td>
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<tr>
<td>Dental Materials Science (1224)(Joint with New York University)</td>
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<tr>
<td>Economic Systems (2204)</td>
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<tr>
<td>Electrical Engineering (0909)</td>
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<td>Electrophysics (0919)</td>
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<tr>
<td>Environment - Behavior Studies (2201)</td>
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<tr>
<td>Environmental Health Science (0922)</td>
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<tr>
<td>History of Science (2205)</td>
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<tr>
<td>Humanities (4003)</td>
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<tr>
<td>Industrial &amp; Applied Mathematics (1703)</td>
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<tr>
<td>Industrial Chemistry (0906)</td>
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<tr>
<td>Industrial Engineering (0913)</td>
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<tr>
<td>Information Management (0702)</td>
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<tr>
<td>Information Systems (0901)</td>
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<tr>
<td>Life Sciences (0401)</td>
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<tr>
<td>Management (0506)</td>
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<tr>
<td>Mathematics (1701)</td>
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<td>Mathematics for Teachers (1710)</td>
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<tr>
<td>Mechanical Engineering (0910)</td>
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<tr>
<td>Metallurgical Engineering (0914)</td>
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<tr>
<td>Metallurgy &amp; Materials Science (0914)</td>
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<td>Nuclear Engineering (0920)</td>
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<td>Operations Management (0510)</td>
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<td>Operations Research (0913)</td>
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<td>Organizational Behavior (0515)</td>
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<td>Physical Metallurgy (1920)</td>
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<tr>
<td>Physics (1902)</td>
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<tr>
<td>Polymer Science and Engineering (0906)</td>
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<td>Journalism of Technical Writing (0602)</td>
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<tr>
<td>Specialized Journalism (0802)</td>
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<tr>
<td>Social Sciences (2201)</td>
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<tr>
<td>System Engineering (0901)</td>
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<tr>
<td>Transportation Engineering (0908)</td>
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<td>Transportation Management (0510)</td>
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<tr>
<td>Transportation Planning and Engineering (0908)</td>
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</table>

*Brookhaven Labs.

Attendance at Brooklyn campus may be required to complete the degree program.

Registered degree program - Brooklyn campus; L.I. registration pending.
ADMISSIONS

UNDERGRADUATE

THE APPLICATION PROCESS

Application materials and information on undergraduate admissions may be obtained by telephoning or writing the Admissions Office at either of the following locations:

BROOKLYN
Admissions Office
Polytechnic Institute of New York
333 Jay Street
Brooklyn, NY 11201
(212) 643-2150

FARMINGDALE
Admissions Office
Polytechnic Institute of New York
Route 110
Farmingdale, NY 11735
(516) 454-5150

Undergraduate applicants should complete the two-part admissions application form and forward it to the Admissions Office with either a $20 non-refundable application fee or a fee waiver request form. Upon submission of the application form, applicants should request their secondary school or college to forward official copies of transcripts to the Polytechnic Admissions Office. All freshmen applicants and all transfer applicants with less than two complete years of college are required to also submit test scores on the Scholastic Aptitude Test (SAT) and Achievement Tests (ACT), or on the American College Testing Program (ACT).

Personal essays and teacher recommendations are welcome, but no longer strictly required.

Polytechnic’s admission process operates on a rolling basis. Preference, however, will be given to applicants who submit all of their documents according to the following timetable:

- Full-time undergraduate study:
  - October 1—for the spring semester
  - February 1—for the fall semester

- Part-time undergraduate study:
  - December 1—for the spring semester
  - August 1—for the fall semester

Candidates for freshman admission to the fall term who submit their applications and all of their documents before January 15 will receive a decision by February 1. Freshman candidates for the fall term who apply after February 1 will receive an admission decision within four weeks after submittal of all documents. Admission of fall freshmen applicants, who apply after February 1 will, of course, depend upon the availability of space at that time.

The preceding timetable does not apply to international applicants. Because of the extra time required to process applications from abroad, consideration will not be given to foreign applications received after November 1 for the spring semester, nor after May 1 for the fall semester. All official records together with notarized translations must also be received by these dates. If accepted for admission, the student should submit an enrollment deposit of $100 in order to reserve a place in the entering class. This fee will be applied to tuition and fees for the first semester. This deposit is not refundable after May 1 for the fall semester, nor after December 1 for the spring semester.

Students who are admitted for the fall semester may begin their studies in the summer session. Polytechnic offers two summer sessions to help students who wish to accelerate or supplement their studies.

THE EARLY ACTION PLAN

Under the Early Action Plan, students may request an admissions decision by December 1, provided that their applications and supporting documents are submitted on November 1. Students admitted under this program are under no obligation to make a commitment to enroll at Polytechnic.

CRITERIA FOR ADMISSION

ADMISSION AS A FRESHMAN

Examinations

Applicants for admission as freshmen are required to take the Scholastic Aptitude Test of the College Entrance Examination Board. In addition, applicants for engineering and science should take achievement tests in English composition, one laboratory science (chemistry or biology) and mathematics level I. Humanities and social science applicants should take achievement tests in English composition and any other two achievements, preferably in the humanities. The American College Testing Program may be substituted for the College Entrance Examination Board's examinations.

Secondary School Record

Inasmuch as the course of studies at Polytechnic is academically rigorous and intellectually challenging,
ADMISSION TO THE UNIVERSITY IS HIGHLY COMPETITIVE. CANDIDATES FOR ADMISSION WILL BE JUDGED PRIMARILY ON THEIR POTENTIAL FOR SUCCESS AT POLYTECHNIC.

THE PREFERRED COURSE OF STUDIES ON THE SECONDARY SCHOOL LEVEL IS:

ENGLISH—4 YEARS
FOREIGN LANGUAGE—2 YEARS
ELECTIVES—4 YEARS (PHYSICS AND CHEMISTRY PREFERRED)
MATHEMATICS—3 YEARS (ELEMENTARY ALGEBRA, GEOMETRY, INTERMEDIATE ALGEBRA, TRIGONOMETRY)
SOCIAL STUDIES—2 YEARS
ELECTIVES—3 YEARS (TECHNICAL COURSES SUCH AS PRE-CALCULUS, CALCULUS, ADVANCED LABORATORY SCIENCE, COMPUTER SCIENCE, ETC., PREFERRED)

THIS COURSE OF STUDIES IS ONLY A DIRECTIVE, NOT AN ABSOLUTE REQUIREMENT; THE PRIMARY CONCERN OF THE MEMBERS OF THE ADMISSIONS COMMITTEE IS IN DETERMINING AN APPLICANT'S POTENTIAL FOR SUCCESS AT THE UNIVERSITY.

ADMISSION AS A TRANSFER STUDENT
POLYTECHNIC WELCOMES TRANSFER STUDENTS FROM ACCREDITED COLLEGES AND UNIVERSITIES, PROVIDED THAT THEY HAVE MAINTAINED A STRONG ACADEMIC RECORD. STUDENTS WHO HAVE NOT COMPLETED TWO YEARS OF COLLEGE WORK SHOULD SUBMIT A TRANSCRIPT OF PREVIOUS COLLEGE GRADES, PLUS THEIR HIGH SCHOOL TRANSCRIPT AND SCHOLASTIC APTITUDE TEST SCORES. STUDENTS WHO HAVE COMPLETED TWO OR MORE YEARS OF COLLEGE NEED ONLY SUBMIT A COLLEGE TRANSCRIPT.

IF ACCEPTED TO THE UNIVERSITY, TRANSFER STUDENTS SHOULD MEET WITH A MEMBER OF THE ADMISSIONS STAFF AND A DEPARTMENTAL ADVISER IN ORDER TO DETERMINE WHICH CREDITS ARE TRANSFERABLE TO POLYTECHNIC. STUDENTS ARE REQUIRED TO SUBMIT COPIES OF COURSE CONTENTS FROM THEIR COLLEGE CATALOG FOR ALL COURSES UNDER CONSIDERATION.

TRANSFER CREDIT IS AWARDED ON THE BASIS OF CURRENT STANDARDS AND CURRICULUM; THEREFORE, IT IS POSSIBLE THAT CREDIT WHICH POLYTECHNIC HAS PREVIOUSLY AWARDED FOR COURSES TAKEN AT OTHER UNIVERSITIES MAY NO LONGER BE AWARDED AT THIS TIME. ALL TRANSFER CREDIT EVALUATIONS ARE TENTATIVE AND CONDITIONAL UPON THE STUDENT DOING ACCEPTABLE WORK AT POLYTECHNIC. A SUBSTANDARD ACADEMIC PERFORMANCE IN A COURSE AT POLYTECHNIC MAY RESULT IN A REQUIREMENT THAT THE STUDENT ENROLL IN, AND PASS, A COURSE FOR WHICH TRANSFER CREDIT WAS PREVIOUSLY GRANTED.

IN CERTAIN INSTANCES, COURSE REQUIREMENTS MAY BE WAIVED FOR STUDENTS WHO DEMONSTRATE SUFFICIENT KNOWLEDGE OF A SPECIFIC COURSE CONTENT THROUGH EITHER THE ORAL OR WRITTEN EXAMINATIONS EMPLOYED BY THE VARIOUS DEPARTMENTS. WHEN COURSE REQUIREMENTS ARE WAIVED, THE STUDENT WILL NOT RECEIVE CREDIT FOR THE COURSE, BUT MAY BE ALLOWED TO SUBSTITUTE A DIFFERENT COURSE, USUALLY ONE WHICH IS MORE ADVANCED, TO SATISFY THE DEGREE REQUIREMENT.

THE GRADES FOR COURSES FOR WHICH TRANSFER CREDIT IS GRANTED ARE NOT INCLUDED IN THE COMPUTATION OF THE POLYTECHNIC GRADE POINT AVERAGE.

THIRTY-FOUR SEMESTER HOURS IN APPROVED UPPER CLASS SUBJECTS TAKEN AT POLYTECHNIC CONSTITUTE THE MINIMUM RESIDENCE REQUIREMENT FOR TRANSFER STUDENTS WHO WISH TO QUALIFY FOR A BACHELOR'S DEGREE.

ADMISSION AS AN INTERNATIONAL STUDENT
PROFICIENCY IN ENGLISH IS A PREREQUISITE FOR ADMISSION AND THE TEST OF ENGLISH AS A FOREIGN LANGUAGE (TOEFL) IS REQUIRED OF ALL STUDENTS WHOSE NATIVE LANGUAGE IS NOT ENGLISH. IN ADDITION, INTERNATIONAL APPLICANTS MUST SUBMIT A STATEMENT OF FINANCIAL CAPABILITY BEFORE BEING PERMITTED TO ENROLL. STUDENTS HOLDING F-1 VISA MUST ENROLL AS FULL-TIME STUDENTS.

IF TRANSFER CREDIT IS DESIRED, THE CANDIDATE MUST INCLUDE CATALOG OR SYLLABUS DESCRIPTIONS OF COURSES COMPLETED. AN OFFICIAL TRANSFER CREDIT EVALUATION WILL BE DONE WHEN THE STUDENT ARRIVES AT POLYTECHNIC AND MEETS WITH A MEMBER OF THE STAFF AND A DEPARTMENTAL ADVISER.

ADMISSION UNDER THE HIGHER EDUCATION OPPORTUNITY PROGRAM
THE HIGHER EDUCATION OPPORTUNITY PROGRAM (HEOP) PROVIDES EDUCATIONAL OPPORTUNITY TO ECONOMICALLY AND EDUCATIONALLY DISADVANTAGED STUDENTS OF NEW YORK. ECONOMIC ELIGIBILITY IS BASED ON FEDERAL ECONOMIC GUIDELINES WHICH TAKE INTO CONSIDERATION FAMILY SIZE, FAMILY MEMBERS WHO ARE STUDENTS AND THE FAMILY INCOME.

INCOMING FRESHMEN IN HEOP ARE REQUIRED TO TAKE SIX WEEKS OF REMEDIAL WORK BEFORE ENTERING TO MAKE UP PREREQUISITES AND COURSES IN WHICH WEAKNESS IS SHOWN.

TRANSFER STUDENTS MAY ENTER HEOP; HOWEVER, ONLY STUDENTS COMING FROM SIMILAR PROGRAMS APPROVED BY THE HEOP CENTRAL OFFICE ARE ELIGIBLE TO TRANSFER INTO THE HEOP PROGRAM. FOR FURTHER INFORMATION, CONTACT THE DIRECTOR OF HEOP AT THE BROOKLYN CAMPUS AT (212) 643-5995. HEOP IS AVAILABLE AT THE BROOKLYN CAMPUS ONLY.

ADMISSION AS A PART-TIME STUDENT
MEN AND WOMEN SEEKING A BACHELOR'S DEGREE IN ENGINEERING MAY ENROLL ON A PART-TIME BASIS AT THE BROOKLYN CAMPUS TAKING DAY OR EVENING COURSES, AND AT THE FARMINGDALE CAMPUS TAKING DAY COURSES. AT THE PRESENT TIME, HOWEVER, ONLY THREE DEGREES CAN BE COMPLETED DURING THE EVENING SESSION AT THE BROOKLYN CAMPUS. MOST STUDENTS WILL BE REQUIRED TO TAKE SOME COURSES DURING THE DAY SESSION IN ORDER TO COMPLETE THEIR DEGREES.

NEW TRANSFER STUDENTS MAY BE ADMITTED ON A PART-TIME OR FULL-TIME BASIS.

REGULATIONS CONCERNING SUBJECT MATTER REQUIREMENTS AND ADMISSIONS PROCEDURES ARE GIVEN IN THE SECTION "ADMISSION AS A FRESHMAN." HOWEVER, PART-TIME UNDERGRADUATE APPLICANTS ARE NOT USUALLY REQUIRED TO TAKE THE ENTRANCE EXAMINATIONS.
Following notification of acceptance, the student should contact the adviser in the student's major department. In some cases, advising may be accomplished during the normal registration period.

Undergraduate students may also register for a maximum of two courses per semester on a non-degree basis. Applications for admission under this special status may normally be obtained during registration. A non-degree program may satisfy the requirements of:

- Applicants for graduate admission seeking courses to satisfy undergraduate or prerequisite deficiencies
- Students seeking specific courses
- Students seeking specialized proficiency in a major area of knowledge
- Students from other colleges wishing to transfer credit back to their college

Courses taken on a non-degree basis are not automatically applicable to a degree program. Some courses, however, may be transferred to a degree program with the approval of a departmental adviser.

FRESHMAN ADMISSION WITH ADVANCED STANDING

Freshmen may receive advanced standing with college credit at Polytechnic by scoring exceptionally well on the Advanced Placement Examinations given by the College Entrance Examination Board. Similar consideration will be given to those with exceptionally good scores on the Higher Level of the International Baccalaureate Exam.

Specific requirements for administering college credit, for both the Advanced Placement and International Baccalaureate Exam, vary from department to department.

Also, through Polytechnic's College Preview Program, students may gain college credit during the senior year in high school. Courses are offered to College Preview students at a reduced tuition rate.

EARLY ADMISSION

On occasion, Polytechnic offers early admission to outstanding high school juniors. Programs can be arranged so that students simultaneously satisfy the requirements for a high school diploma while completing the first year of college. Candidates for this program must complete their entrance examinations in their junior year of high school, and they must present, together with their application, a letter from their high school principal stating the secondary school's approval.

INTERVIEWS AND CAMPUS TOURS

Prospective students are strongly encouraged to visit the campus of their choice. Arrangements can be made by calling the admissions office at either campus. Provided that arrangements are made in advance, prospective students are also welcome to have an interview with a member of the admissions staff during the time of their visit to Polytechnic. The interview is no longer strictly required as a condition for admission, but it is generally a useful process for both the applicant and the admissions staff.

GRADUATE

To be eligible for admission as a graduate student, an applicant must hold a bachelor's degree from an institution acceptable to Polytechnic. Attention will be given to listings by the Accreditation Board for Engineering and Technology, the American Chemical Society, and the various regional accrediting associations. Applicants wishing to enter a graduate field different from the undergraduate field in which they hold a bachelor's degree, or its international equivalent, must anticipate the possibility of some make-up courses for which they may not receive graduate credit.

The previous program of studies must be acceptable, in quality and quantity, to Polytechnic. Reprints of published articles, copies of scientific patents, photostats of professional reports and other evidences of superior attainment and aptitude for graduate study and research are welcomed.

Graduate admission information can be obtained from the Research and Graduate Affairs Office, 333 Jay Street, Brooklyn, NY 11201, (212) 643-3693.

ADMISSIONS PROCEDURES

In addition to the application form and fee, applicants must have transcripts of any previous undergraduate record (and graduate record) sent directly to the Graduate Affairs Office. Applications for admission should be supported by letters of recommendation by persons who are well qualified to comment on the applicant's aptitude for graduate study and research. Action on applications will be taken as soon as possible after all supporting papers have been received.

In special instances, qualified admission is given to students who lack some of the prerequisites. These deficiencies must then be removed by prescribed undergraduate courses, which may be taken at Polytechnic or another acceptable institution.

EXAMINATIONS

Applicants for the graduate programs in chemistry, chemical engineering, and polymer science and
engineering are required to take the Graduate Record Examination.

All applicants for studies in management are required to take the Graduate Management Admissions Test administered by the Educational Testing Service.

Information about both examinations may be obtained by contacting the Educational Testing Service, 20 Nassau Street, Princeton, NJ 08541.

INTERNATIONAL APPLICANTS

An international applicant must have a complete file by May 1 (fall term), October 15 (spring term) or March 1 (summer term) to be reviewed for the term of entrance requested. An incomplete file will delay review, and, therefore, entrance by at least one term. The Test of English as a Foreign Language (TOEFL), administered by the Educational Testing Service, Princeton, NJ, as well as a certification of ability to meet financial obligations are required of all international applicants.

STATUS

Within the full-time and part-time classification of graduate students, there are five status groups: degree status, nondegree status, graduate probation status, provisional and special status. Changes from nondegree status to degree status must be approved by the Graduate Affairs Office. Graduate special and provisional students must apply for and be admitted to degree or nondegree status through the Graduate Affairs Office.

Degree Status. This status is assigned to applicants who apply for a degree program and whom Polytechnic considers adequately prepared for and capable of such study. Students are admitted to degree status upon the recommendation of their major department of study.

A student who applies without former graduate studies must have earned a bachelor's degree from a fully approved college or university (including professional accreditation). To attain degree status immediately at the time of acceptance into Polytechnic's graduate school, a student must have maintained an acceptable average in the major field of study.

Qualification for degree status of continuing students is reviewed yearly by the Graduate Affairs Office. If a cumulative B average is not maintained, the status is changed to nondegree status.

Nondegree Status. This status is generally assigned to applicants who are asked to provide additional demonstration of the ability to pursue a graduate degree program—specifically by achieving A or B grades (minimum requirement of a B average) in at least 12 units of graduate courses. After satisfying the requirements specified at admission, the student will, upon written request and the approval of the major department, be transferred to degree status. Change of status forms are available in the Graduate Affairs Office. All of the courses successfully completed which are normally required of that degree program will apply toward satisfying the degree requirements.

This status is also awarded to applicants with advanced degrees who are entering a new professional area and desire extended education, but not for degree purposes. This includes students enrolling in Graduate Certificate Programs. However, should they so desire, students in this status may later request transfer with full credit to degree status.

Graduate Probation Status. Graduate students are expected to make satisfactory progress in the program of studies pursued and to maintain a B (3.0) average. Failure to do so can result in "academic probation." For the purposes of computing graduate grade-point averages, the following schedule will be used:

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<thead>
<tr>
<th>Letter Grade</th>
<th>Grade-Points</th>
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<tbody>
<tr>
<td>A</td>
<td>4.0</td>
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<tr>
<td>B</td>
<td>3.0</td>
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<tr>
<td>C</td>
<td>2.0</td>
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<tr>
<td>F</td>
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Courses repeated will count only once in the grade-point average, with the highest grade included.

After the posting of spring grades, all graduate students whose grade-point averages are below 3.0 will be notified that they are on academic probation. The data for such determination will be provided by the Office of Student Records and copies of all probation notices will go to the department, which will check the accuracy of the grade-point determination.

In addition, the department may, at its discretion, request that a student be placed on academic probation at any time it finds a student falling below a 3.0 grade-point average. The request must be signed by the department head, and is sent to the graduate affairs office.

A graduate student on academic probation may not register for further courses without the written permission of the department head and concurrence of the Graduate Affairs Office. When such a student is permitted to register, the department will provide the student with a written statement of the academic performance required for the next academic year or semester in order to retain permission to register in future semesters. This statement will be kept on file in both the Graduate Affairs Office and the departmental office. Students may be denied permission to register by their department or the graduate affairs office at any time while they are on academic probation. Students are cautioned that failure to maintain a 3.0 grade-point average may result in the loss of degree status and/or in refusal of permission to register.

No indication of academic probation will appear on the student's transcript, but a record will be kept on file.

Special Student Status. The Special Student category accommodates students who want to take one or two courses before making a commitment to a degree program, or who wish to take courses for professional development or personal enrichment. Students who wish to eventually obtain a degree should submit a formal application for admission during the initial semester of
enrollment. Students must complete a Special Student application for each semester of attendance. No more than nine credits or three courses may be transferred into a degree program.

Provisional Status. On occasion, a decision on a student’s application may be delayed. Such a student may be temporarily accepted and allowed to register for one semester pending a decision. If the student is not accepted, he/she has the choice of withdrawing with a full refund or finishing the semester, but will not be allowed to register again.

A student has six weeks after registration to submit all necessary documents.

EARLY GRADUATE ADMISSION

A Polytechnic undergraduate who is within 18 credits of completing the B.S. degree and otherwise meets criteria for admission to graduate degree status in a department at the Polytechnic may apply for conditional admission to graduate study in that department. If accepted, the student will simultaneously be pursuing two degrees, taking both graduate and undergraduate courses for no longer than one year. Graduate courses taken during that year, and not used to satisfy undergraduate degree requirements, are not included in the nine credit transfer limit for Master’s degree programs.
Polytechnic Institute administers a broad range of scholarship and financial aid programs designed to assist students in pursuing their educational goals. To meet the total cost of education, the student may draw upon available sources (e.g., student income, family income, the Polytechnic Institute and independent and government funds).

All financial aid is limited to the needs of the student as determined by the College Scholarship Service. Students receiving financial assistance from the Polytechnic Institute must notify the director of financial aid of all scholarships, loans, and other forms of educational assistance from sources other than those directly administered by the Office of Financial Aid.

There are three basic types of financial aid:

**Scholarships and grants**—Funds awarded to students based on a combination of academic ability and financial need which do not require repayment.

**Loans**—Specific sums awarded to students with repayment conditions. Education loans generally have a low interest with extended repayment terms.

**Employment**—Part-time and summer jobs either on or off campus.

About 80 percent of Polytechnic’s undergraduate students receive aid in combinations of scholarships, grants, campus jobs, National Direct Student Loans, and Guaranteed Student Loans.

### To Apply

1. First-time college students should file the complete Financial Aid Form (FAF) with the College Scholarship Service, Princeton, New Jersey, by February 1. (Later applications are considered on a rolling basis as funds are available.)

2. Transfer students should file the FAF by March 1, and request a financial aid transcript from the transferring institution to be sent to the Financial Aid Office at Polytechnic Institute by March 15.

### To Renew

1. Request the Financial Aid Form from the Director of Financial Aid in February.

2. File the FAF with the College Scholarship Service, Princeton, New Jersey, by April 1.

3. File the Polytechnic Institute Financial Aid Application with the Office of Financial Aid by April 15. A copy of the parents’ 1040 or 1040A and/or the student’s 1040 or 1040A tax form for the previous calendar year must accompany this application.

### FEDERAL BASED PROGRAMS

#### Supplemental Educational Opportunity Grants (SEOG)

**Application procedures.** Awards are determined by Polytechnic’s Financial Aid Office. Students must be accepted and have filed the FAF with the College Scholarship Service.

**Selection and allocation.** The applicant must be (1) needy, and (2) enrolled at least half-time as an undergraduate student.

**Award schedule.** The award ranges from $200 to $2,000. Normally an award may be paid for up to four years, or up to five years for certain courses of study.

**Rights and responsibilities.** The student must continue to make satisfactory academic progress.

#### National Direct Student Loan Program (NDSL)

**Selection and allocation.** Loans are available to needy students enrolled at least half-time.

**Award schedule.** Amounts which may be borrowed are $3,000 by students who have completed less than two years of a program leading to a bachelor’s degree; and $6,000 by students who have completed two years toward a bachelor’s degree, to include any amount borrowed through an NDSL for the first two years of study.

**Rights and responsibilities.** The current interest rate, payable during the repayment period, is 5% on the unpaid principal. Repayment begins six months after graduation or after leaving Polytechnic and may extend up to ten years. The minimum monthly payment is $30. Payment is not required for up to 3 years of active U.S. military service, or service in Peace Corps, VISTA, or similar national program.

#### College Work-Study Program (CWSP)

**Application procedures.** Awards are determined by Polytechnic’s Financial Aid Office. Students must have
or part-time.

Award.

Before receiving payment, the student must sign an agreement stating that the student will continue to make satisfactory academic progress and that the student must not owe refunds on student aid. The amount of the award is determined, work arrangements are made through the Student Employment Office.

Selection and allocation. The applicant must be enrolled at least half-time. Polytechnic provides employment to eligible students who demonstrate financial need. If more students are eligible for the CWSP than there are funds available, preference is given to students with greater need who must earn a part of their educational expenses. Generally, the CWSP is not available to students in their freshman year.

Award schedule. Polytechnic arranges jobs on or off campus with public or private nonprofit agencies. Most assignments average 15 hours per week.

Rights and responsibilities. Satisfactory academic progress must be maintained.

Pell Grants
(formerly Basic Educational Opportunity Grants)

Application procedures. Applications and other materials are available through the Financial Aid Office. The application should be completed according to directions or a student should apply for the Pell Grant by checking the appropriate box on the Financial Aid Form (FAF). A student eligibility report will be sent to the applicant from the Department of Education. Based on an eligibility index the amount of the applicant's Pell Grant is determined by the Financial Aid Office. Upon enrollment, funds are paid directly to the Institute in the student's name.

Selection and allocation. The Pell Grant program is an entitlement program. Scholastic accomplishment has no bearing on eligibility. The applicant must be enrolled as an undergraduate at least on a half-time basis. Financial need for the Pell Grant is determined by a formula developed by the U.S. Department of Education and reviewed annually by Congress. The formula is applied to all applicants, and the student eligibility index is calculated by this formula.

Award schedule. Currently, awards range from $200 to $1,800, but not more than one-half the total cost of attendance. The amount of the award will be affected by costs of attendance and full- or part-time enrollment status. The Pell Grant award does not duplicate state awards.

Rights and responsibilities. The student must continue to make satisfactory academic progress and must not owe refunds on Pell or other awards paid, or be in default on repayment of any student loan. Before receiving payment, the student must sign an affidavit that all money will be used for the costs of attendance only. Most Pell Grant payments are credited directly to the student's Institute account.

Veterans Administration (VA)
Education and Benefits

Application procedures. Applications are available at all VA offices, active duty stations and American embassies and in the Office of Student Records. Completed forms should be submitted to the nearest VA office.

Veterans Information. All veterans enrolled at Polytechnic should notify the Veteran Affairs clerk in the Office of Student Records of the credits to be attempted during a semester. Any questions concerning veteran's benefits or paperwork should be directed to the Veteran Affairs clerk, either in person or by telephone.

Selection and allocation. Veterans who served on active duty, (2) were honorably discharged at the end of their tour of duty, or (3) qualify because of service connected disabilities, are eligible for benefits. Veterans are entitled to benefits for full-time study at an approved post-secondary institution for one-half months for each month of active service (up to 45 months). Eligible veterans who served 18 continuous months are entitled to benefits for 45 months of full-time study. In each case, the equivalent in part-time study may be authorized. Eligibility extends for ten years after release from service, but not after December 31, 1989. Children, spouses and survivors of veterans whose deaths or permanent total disabilities were service-connected, or who are listed as missing in action, may be eligible for post-secondary education benefits under the same conditions as veterans.

Award schedule. Current monthly benefit rates are available through VA offices. Veterans may borrow up to $2,500 for an academic year of full-time study through a special loan program for veterans.

Rights and responsibilities. Institutions are required to report any interrupted attendance or termination of study on the part of students receiving benefits to the VA. Details of the Institute's requirements are given to each applicant. Eligible students must apply for certification each semester in the Office of Student Records.

ROTC Scholarships

Army and Air Force ROTC offer four-, three-, and two-year scholarships. The four-year scholarships are awarded on a competitive basis to U.S. citizens who will be entering college as freshmen. The three- and two-year scholarships are awarded competitively to students who are enrolled in college and are academically aligned with an ROTC program. Students who attend basic camp of the two-year program may also compete for two-year scholarships. The scholarships pay for tuition, textbooks, lab fees, plus a living allowance of up to $1,000 each year the scholarship is in effect.

NEW YORK STATE BASED PROGRAMS

Tuition Assistance Program (TAP)

Application procedures. Applicants must apply annually to the State Higher Education Services Corporation (HESC), 99 Washington Avenue, Albany, NY 12225. The application deadline for the 1983-84 academic year is March 31, 1984. The HESC determines the applicant's eligibility with an award
certificate indicating the amount of the grant. The applicant presents the institutional copy of the certificate when tuition is paid. Polytechnic will defer payment upon receipt of the award certificate.

Selection and allocation. TAP is an entitlement program. The applicant must (1) be a New York State resident and a U.S. citizen or permanent resident; (2) be enrolled full-time at an approved New York State post-secondary institution; (3) have, if dependent, a family net taxable income below $25,001, or if independent and single with no tax dependents, a net taxable income below $5,667, and (4) be charged a tuition of at least $200 per year.

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

Award schedule. The amount of the TAP award depends on the level of study, tuition charge, and net taxable income. (This income is adjusted to reflect other family members enrolled full-time in post-secondary study.) For the 1983-1984 academic year, full-time dependent students can receive awards ranging from $260 to $2,200.

Regents College Scholarship

Application procedures. Applicants may obtain application forms from their high school.

Selection and allocation. Regents College Scholarships are awarded on a competitive basis. The applicant must (1) have been a legal resident of New York State for at least one year immediately preceding the first term for which application of an award is made, (2) be in attendance in a high school within six years in which the examination was taken; and (3) not previously have competed for a Regents Scholarship.

Award schedule. The Award is $250 per year for up to five years, depending on the normal length of the program in which the recipient is enrolled.

Polytechnic Matching Grants have automatically been awarded to freshmen and transfer students entering on or after September 1980, even if the student is ineligible for other financial aid. The matching grant is equal to $250.

Guaranteed Student Loan Program

Application procedure. The student should obtain a loan application from a participating state lending institution (bank, credit union, etc.) in the student’s state of permanent residence. The completed application should be presented to the Polytechnic Financial Aid Office for certification. The application is then forwarded to the lending institution and the appropriate state agency.

Selection and allocation. To be eligible for a guaranteed state loan, a student must (1) be a U.S. citizen or permanent resident alien, and (2) be enrolled in or admitted at least half-time to an approved post-secondary institution.

Loan schedule. An undergraduate may borrow up to $2,500 per year, up to a total of $12,500.

Rights and responsibilities. A student may borrow at a relatively low interest rate (currently nine percent) with no repayment as long as the student remains enrolled at least half-time. Payment of the principal may be further deferred during graduate study, service in the Armed Forces, or during full-time Peace Corps or Domestic Service service.

If a student applies for an additional loan, application must be made to the original lending institution. Four months after ceasing to be at least a half-time student, the borrower must make formal arrangements with the lending institution to begin repayment.

SCHOLARSHIPS AND GRANTS

Polytechnic has a history of scholastic recognition to numerous applicants with outstanding academic credentials. The dollar value of such awards is based on need, academic achievement, recommendation and outside awards.

Polytechnic Scholarships are usually awarded to students who have a strong academic background and demonstrated financial need. Normally a freshman student must have combined SAT scores of 1200 and a high school average of 90 to be considered for a Polytechnic Scholarship. Transfer students must have at least a 3.0 grade-point average to be considered for a Polytechnic Scholarship.

Board of Trustee Scholarships are awarded to the most academically superior freshman applicants. The amount of the scholarship is equal to tuition, less any outside aid for which the student is eligible.

IMPORTANT FINANCIAL AID POLICIES

• To be eligible to receive financial aid, a student must be enrolled at least half-time. All Polytechnic Scholarships, TAP grants, and Regents Scholarships, however, require a student to be full-time to qualify.

• Financial Aid applicants are expected to apply for a Pell Grant, and in the case of New York residents, for the Tuition Assistance Program.

• Although at Polytechnic the Admissions and Financial Aid Offices are associated, admissions decisions are not affected by financial aid decisions. Admissions officers do not have access to financial aid records. Their academic evaluation of a student’s qualifications are made without knowledge of the applicant’s financial need.

Prospective students should, however, not wait until they have been admitted to apply for financial aid. These are concurrent processes. Applicants should
make every effort to apply for admissions and financial aid by the preferred application dates. Once students are admitted, they are then reviewed for financial aid.

- Financial aid is renewable annually, based on a student reapplying, continuing to demonstrate financial need where applicable, and fulfilling any other requirements stipulated by the award. To renew most, Polytechnic scholarships, a student must maintain a 2.5 cumulative grade-point average. To renew a Board of Trustee scholarship, a student must maintain a 3.0 cumulative grade-point average.

- Since financial aid and scholarship funds administered by the Institute are limited, students should be aware that it is very unwise to enroll at Polytechnic without financial aid support, on the assumption that at a later date financial aid will be available. Given a fixed amount of resources, the Institute does not deem it ethical to withdraw support from students who may have based their decision to attend Polytechnic on the financial aid they were awarded in order to free up money to assist new applicants later on. Funds from financial aid programs not administered by the Institute, such as the Pell Grant Program, TAP, and the Guaranteed Student Loan Program, are available to eligible students regardless of whether a student received funds from these programs upon entry into the Institute.

Satisfactory Academic Progress Requirement

During the academic terms in which a student is receiving financial aid from federal or state sources, he or she must be progressing toward a degree according to the standards set forth in the Academic Policies section of this catalog.

"Terms of eligibility" for financial aid are calculated as the total time of a student's enrollment at any institution. Students, therefore, can be making satisfactory progress toward their degree, but potentially can exhaust their eligibility for financial aid from New York State by not completing their degree requirements within the eight-semester "terms of eligibility."

A student may request a waiver of the standard of minimum satisfactory progress during one term. Such a request should be made to the Dean of Student Life.

GRADUATE

GRADUATE FELLOWSHIPS AND ASSISTANTSHIPS

Fellowships and assistantships are available for advanced study leading to the master's, engineer, or doctor's degree in engineering and science disciplines. Applicants must hold a degree from institutions of recognized standing. New students can apply by completing the appropriate question on the "Application for Graduate Admissions" form; a continuing student should consult the department.

Research Fellowships

Fellows are assigned to research, leading to the fulfillment of the thesis requirement of the graduate curriculum in which they matriculate while pursuing a full-time program of studies. Tuition during the academic year is remitted.

Teaching Fellowships

Fellows are full-time graduate students who participate half-time throughout the academic year in teaching assignments. Tuition during the academic year is remitted.

Special Fellowships

There are available a number of special fellowships sponsored by industry and foundations. Information may be obtained from the departmental office concerned.

UNDERGRADUATE GRANTS AND SCHOLARSHIPS

| American Waterworks Society | The W. E. Fay Scholarship |
| New York Section | Geismar Industries Inc Scholarship |
| David Bregman Award | Handy and Harmon Corporation Scholarship |
| ARCO Corporation Scholarship | Helmer Helwig Scholarship |
| The J. B. Obermayer Scholarship | International Precious Metals Institute Scholarship |
| The Arthur Clapp Scholarship | The Eugene R. Kulka Scholarship |
| Atlas and E. Y. DeGates Scholarship | The John F. Kunc Scholarship |
| The Deloitte Scholarship | The P. R. Mallory Memorial Scholarship |
| The Aaron and Zinna Dwyer Scholarship | Materials Research Corporation Scholarship |
| The W. F. Dwyer Scholarship | Raymond Mauro Scholarships |
| The A. S. Dwight Scholarship | The NSC-Essie Mitchell Scholarship |
| EMMCO Development Corporation Scholarship | The Coors Foundation Scholarships |
| The Alfred L. Fried Scholarship | The William Nichols Scholarship |
| The D. P. Freitas Scholarship | The Nippon Electric Corporation Scholarship |
| United Steelworkers Scholarship | Off Corporation Scholarship |
| The ERMAK Corporation Scholarship | Sperry Rand Scholarship |
| The Ernst and Sonya Weber Gratz | Myron Rozenson Scholarship |
| The H. J. Sperry Institute Scholarship | Samuel Rutenber Scholarship |
| The J. A. Sweeten Scholarship | Singer Company Scholarship |
| The L. E. Templeton Scholarship | The Frank R. and Emily E. Seaver Scholarships |
| The Lee H. Whitney Scholarship | Institute Trustee Scholarships |
| The L. S. Sibley Scholarship | United States Steel Foundation Scholarships |
| The M. R. and Emily E. Seaver Scholarships | The First and Sonja Weber Grants |

The J. B. Obermayer Scholarship

The P. R. Mallory Memorial Scholarship

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The Nippon Electric Corporation Scholarship

Off Corporation Scholarship

Singer Company Scholarship

The Frank R. and Emily E. Seaver Scholarships

Institute Trustee Scholarships

United States Steel Foundation Scholarships

The First and Sonja Weber Grants
Graduate Assistantships

Opportunities are available to full-time doctoral students who have completed 90 graduate units including all dissertation research credits to work on sponsored research projects. Assistants devote full-time to research leading to the fulfillment of the doctoral research requirement of the graduate curriculum in which they matriculate.

Reduced Tuition Programs for High School and College Teachers

A reduced tuition program is offered for high school and college teachers to encourage their pursuit of graduate studies at Polytechnic. The plan provides a tuition reduction of one-third for graduate courses taken at any campus leading to an advanced degree on a part-time basis. This tuition reduction offer is not available to students with "special" status.

The applicant must be accepted in a graduate program through the formal Polytechnic admissions procedure. Written verification of employment as a high school or college teacher, signed by the applicant's department head and an officer of that institution, must be submitted at each registration. The policy is not retroactive, and students may not participate in more than one tuition reduction or remission program.

This policy is subject to annual review.
TUITION AND FEES

Current information on tuition and fees is available in the course schedule bulletin available prior to the start of each semester. The student records, bursar, and admissions offices also have up-to-date cost data available.

For fall 1983, full-time tuition for undergraduate students (12 to 20 credits) will be $3,550 per semester. Students enrolled for fewer than 12 undergraduate credits will pay $220 per credit. Full-time tuition for graduate students will be $3,650 per semester and for part-time graduate courses, $240 per unit.

Credits in excess of 20 must be paid for individually at the per credit rate.

The Polytechnic Corporation reserves the right to alter tuition charges with appropriate notice to students. Such alterations are announced in the Polytechnic Course Bulletin, published as supplements to this catalog twice a year: spring and summer/fall.

Tuition covers the instruction costs, use of the libraries and the facilities of the Student Center. Laboratory fees, ranging from $10 to $75 per semester, are charged for various laboratory classes. Details of these charges are found in the Course Bulletin, inasmuch as they may vary from semester to semester. Courses requiring lab fees are indicated in the course listings.

Other fees, also detailed in the Course Bulletin, include student activity fees, application and acceptance fees, transcript charges, diploma fees and fees for special examinations and dissertations. Housing charges vary according to arrangements at Brooklyn and Farmingdale. For details, consult the Office of Dean of Student Life.

The bursar collects all payments that are due at Polytechnic Institute. Full tuition and fee payments are due from all students at the time of registration. Payments must be made by check or money order. Evidence of any financial aid should be presented at registration. (Visa and MasterCard are accepted.)

Deferred Payment

The college does not have a deferred tuition plan. However, outside agencies do provide independent tuition deferment arrangements. Information on these agencies may be obtained through the Polytechnic admissions office. Special education loan programs enabling the family of the student to repay over an extended period in monthly installments are available at many neighborhood banks. Also, families may qualify for a New York State Higher Education Assistance Loan. Applications are available at local banks. Processing of these loans normally takes from six to eight weeks.

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<thead>
<tr>
<th>ESTIMATED TOTAL COSTS— ACADEMIC YEAR 1983-84</th>
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<tr>
<td>FOR UNDERGRADUATE STUDENTS</td>
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<td>Tuition and Fees</td>
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<td>Room and Board</td>
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<td>Books and Supplies</td>
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<tr>
<td>Transportation</td>
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<tr>
<td>Personal Expenses</td>
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<td>Total:</td>
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<tr>
<th>ESTIMATED EDUCATIONAL COSTS— ACADEMIC YEAR 1983-84</th>
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<tr>
<td>FOR INTERNATIONAL STUDENTS*</td>
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<tr>
<td>Tuition and Fees</td>
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<td>Room and Board</td>
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<td>Personal Expenses</td>
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<td>Insurance**</td>
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<td>Books and Supplies</td>
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<tr>
<td>Total:</td>
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REFUND OF TUITION

Each student, upon registration, assumes obligation for the semester's tuition and other fees. In the event of withdrawal, the right to a refund must not be assumed. Whenever a student withdraws from a course or from all courses, the tuition charges are adjusted according to the schedule outlined below provided (1) the withdrawal notice is filed within the refund period, (2) it is submitted in writing to the student records office and (3) the withdrawal lowers the student's program to less than 12 credits. Forms for this purpose are available in the Office of Student Records. The filing of a withdrawal form in that office is sufficient notification to the school that an adjustment in the records is to be made.

The official withdrawal date is the date the notice of withdrawal is received in the Office of Student Records, not the last date of class attendance.

A refund must be requested from the bursar's office in writing. If no request is received, the refund amount will be credited to the student's account.

*Subject to change. Does not include expenses for dependents.
**For single students. Family coverage is available at additional cost.
Refund Schedule:

The refund schedule is applicable only during the first four weeks of the semester. If the student makes official withdrawal from all courses at the Institute before the first day of classes, there is no charge; otherwise, the following is applicable.

<table>
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<tr>
<th>Withdrawal during</th>
<th>% Charge</th>
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<tbody>
<tr>
<td>First week of semester</td>
<td>10%</td>
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<tr>
<td>Second week of semester</td>
<td>25%</td>
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<tr>
<td>Third week of semester</td>
<td>50%</td>
</tr>
<tr>
<td>Fourth week of semester</td>
<td>75%</td>
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<tr>
<td>After the fourth week of semester</td>
<td>100%</td>
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</table>

Two months after the start of classes must be allowed for the processing of credit and refunds.

Appeals to the refund schedule must be submitted in writing, with documentation of reasons that an exception should be made, to the Director of Student Records.
REGISTRATION

Polytechnic Institute endorses the concept of a close faculty-student relationship and as such the faculty advising system serves as the basis for a student selection of courses and registration. Each academic department identifies a group of faculty to serve as student advisers. In advance of registration, students should meet with their individual advisers and receive approval for their anticipated program of study. A list of advisers and their office numbers may be obtained from each respective departmental office or the Dean of Student Life.

Information on registration and registration appointments are mailed to continuing students prior to the registration period.

Procedure

All continuing full-time students (graduate and undergraduate) must pre-register for the next semester during the middle of each ongoing semester. Continuing full-time students who do not pre-register will be charged $25 late fee.

For the award of academic credit, registration is required each semester for every course, including thesis. Attendance in class does not constitute registration. Registration becomes valid only after payment of appropriate tuition and fees to the bursar and certification by the Office of Student Records.

To qualify for credit students must fill out registration forms, prepare their program of study, have their course selection approved by their faculty adviser, pay the appropriate tuition and fees to the bursar, and have their registration forms accepted by the Office of Student Records, according to published deadlines.

Add/Drop (Registration Change)

Additions or deletions may be made to a student’s program only during the first five class days of the fall and spring or summer semesters. Students may obtain an add/drop form from the Office of Student Records. To add or drop a course, the student must have the written approval of the major adviser.

It is each student’s responsibility to register for a conflict-free schedule. In instances of student-scheduled conflicts that necessitate course changes after registration, the add/drop fee will not be waived.

A fee will be charged for adding or dropping courses or changing sections, except where scheduled changes are necessitated by course cancellations, section adjustments, and other administrative changes.

Students may not add or change courses within the freshman English program or change sections within the freshman mathematics program without the permission of the respective directors of these programs. Authorized changes within these two programs will be allowed through the fourth week of the semester.

Final Day for Registration

Students are expected to complete registration during the official registration period, but must complete registration by the end of the fifth class day of the semester as indicated in the academic calendar. Students who do not complete registration by the end of that day of the semester will not be admitted until the following semester, except by special permission of the dean of the appropriate academic division and the course instructor.

Students who register after the official registration period will be charged a late registration fee. This fee may be waived by the Director of Student Records in clearly justifiable cases.

Course Prerequisites

To be eligible for admission to an advanced course, students should have passed all subjects prerequisite thereunto as listed in the description of courses. If, however, they are deficient in but one such prerequisite course, they may apply to their adviser for admission to the advanced course. If these applications are approved by the adviser and by the teachers of the advanced and prerequisite courses, the student may be admitted to the advanced course.

Student Identification

Each student is required to carry and maintain at all times a photo-identification card issued by the Office of Student Records. This photo-ID must be presented at each registration for validation and shown to a staff member of the Office of Student Records when making changes in registration or requesting transcripts. ID must be presented and/or surrendered to any official of the Institute upon request.

A student ID number is used to identify individual records (billing payments, grades, etc.) for the student’s entire stay at Polytechnic. From the time of admission to the completion of degree, the student ID number is sometimes a social security number but not always. If a student does not have a social security number when admitted (as in the case of international students), the student is assigned a number by the Admissions Office. The assigned number will be permanent throughout the student’s career at Polytechnic and will not be changed, should the student obtain a social security number.
DEGREE REQUIREMENTS

CREDITS AND UNITS

Undergraduate semester credits are based upon the number of 55-minute periods scheduled each week for one semester. Normally one credit signifies either one 55-minute period of class work or three hours of undergraduate laboratory, over a period of 14 weeks.

Graduate studies are expressed in terms of units. One 55-minute period of graduate class work for a semester carries 1½ graduate units. A standard course meeting 2½ academic periods a week would be equivalent to three units. Courses meeting more or less than 2½ academic periods a week carry a proportionate evaluation.

CREDIT FOR COURSES TAKEN ELSEWHERE

Undergraduate

Students entering Polytechnic with advanced standing will receive an appraisal of substitutions allowed based upon credits transferred from their former college. Senior subjects or their equivalent, determined in consultation with the departmental adviser, are to be taken at Polytechnic. The minimum residence requirement for the bachelor's degree is one continuous year of full-time study or the equivalent part-time. See page 16 for further details concerning undergraduate transfer credit policies.

Graduate

A limited amount of credit for graduate courses completed with honor grades (A or B) by students from acceptable institutions may be allowed toward meeting the requirements for either the master's or the doctor's degree provided these courses were acceptable at those institutions for similar degrees and usually after obtaining the bachelor's degree. Such transfer credit is determined by the department.

Graduate courses taken at Polytechnic, while a student is pursuing an undergraduate degree at Polytechnic, subsequently may be applied toward a graduate degree if those courses were not used to fulfill the undergraduate degree requirements. Such courses are considered to be transfer credits, subject to the nine unit limitation for master's degree, since the student was not in residence as a graduate student when the courses were taken.

Transfer Credit While in Residence

To obtain credit for courses taken elsewhere while in residence at Polytechnic, written permission must be obtained from the academic adviser and the department head(s) of the course(s) for which credit is requested, before the start of the course (forms for such permission are available in those offices.) The following requirements may apply:

• The other institution must be accredited
• The grade earned must be at least C for undergraduate courses and B for graduate courses
• Pass/fail courses are not acceptable
• Only the credit will be granted (the grade is not computed in the cumulative average)

It should be noted that in most cases authorization to take courses at another school is required from the appropriate academic dean at Polytechnic.

REQUIREMENTS FOR THE BACHELOR'S DEGREE

In each of the fields of concentration, a program of study (curriculum) is prescribed. The student is admitted to and registers in one of these programs. Subsequent transfer to another program requires approval by the new department. The changes become official only after the proper form has been received by the Office of Student Records. To qualify for the degree, the student must complete the program as outlined in each departmental section in this catalog.

Institute Degree Requirements—in the humanities and social sciences, the student must take HU 101 and either HU 200 and SS 104 or IS 140 and IS 141. Students who are placed in HU 103 on the basis of the English Composition Placement Test administered at Polytechnic to all incoming students may substitute HU 103 for HU 101. Students placed in HU 008 or HU 009 must complete this non-credit writing course before taking HU 101 (or HU 103).

Each undergraduate student is required to complete four semesters of Physical Education (no credit). ROTC courses (MS 101, 102, 201, 202) may be substituted for Physical Education.

Humanities and Social Science Requirements—in addition the student is strongly urged to select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religion in the Department of Humanities and Communications, or political science, economics, history, anthropology or psychology in the Department of Social Sciences) and elect two or three courses in this concentration, in consultation with the departmental adviser. A modern language may be chosen as a suitable concentration but a student without prior knowledge of the language must plan to devote at least 12 credit hours to the subject.

For the remaining credits in the humanities/social sciences requirement, the student should select courses in areas other than that of concentration. Additional courses in humanities and social sciences may be taken as free electives.
Degree Requirements

A student is required to fulfill the following three conditions in order to be certified for a bachelor's degree.

- Fulfill all Institute and departmental course requirements.
- Earn the required number of credits for the Degree Program.
- Have a 2.0 cumulative grade point average.

Bachelor's Degree Audit

During the second semester of the student's junior year, a degree audit check list is sent to the student showing the courses passed as well as those required to satisfy graduation requirements. Because of curriculum and course changes from time to time, it is occasionally necessary for students to request course substitutions to meet their degree requirements. Variations from the required curriculum must be requested in writing and approved in advance. Such requests should be made to the adviser in the major department on a course substitution form available from the Office of Student Records and approved by the dean of the academic division in which the student is majoring.

Part-time students who complete their courses within eight years of continuous residence may qualify for their degrees under the requirements that prevailed at the time of their original registrations. In the case of transfer students, the eight-year period of residence is proportionately reduced. At the expiration of this residency, continuing students may be obliged to obtain revised lists of courses to include those that have been introduced into the curriculum during the eight-year period.

Whenever students interrupt the continuity of their residence by a period of one year or more, they must meet the requirements for degrees in effect at the time of their reregistration unless they have been granted a leave of absence for military service.

Senior Honor Students

Each spring, the departments may select those students with high grade point averages who will complete their B.S. requirements during the following year. Those students are listed as Honor Students in the commencement program for the spring when they are selected, and they are given special permission to make substitutions in their selection of senior year courses (e.g., substituting more advanced or graduate courses in place of the usual requirements).

To be eligible for this designation, transfer students must be scheduled to complete at Polytechnic at least one-half of the credits used to satisfy degree requirements.

Degrees with Honors

Degrees with honors will be awarded at commencement to undergraduate students of high scholastic rank upon unanimous recommendation of the faculty. Honors will be based upon the following cumulative grade-point averages:

- Degree cum laude: 3.40 to 3.59
- Degree magna cum laude: 3.60 to 3.69
- Degree summa cum laude: 3.70 or higher

To be eligible for degrees with honors, transfer students must complete at Polytechnic at least one-half of the total number of credits required for the particular degree.

Requirements for the Master's Degree

Each student qualifying for the master's degree must complete not less than 36 units of advanced study and research in the program elected. To obtain any graduate degree or certificate, the student must have a 3.0 grade-point average or better in all graduate courses and a B or better average in all guided studies (readings, project, thesis, dissertation).

A student may offer no more than 12 units of project or thesis toward the degree requirements. Registration for project or thesis must be continuous until a grade is recorded.

A maximum of nine units may be accepted as transfer and validation credits, the latter not to exceed six credits. All requirements for the master's degree must be completed within a period of five years after beginning graduate study at Polytechnic. Any extension of this period requires the recommendation of the departmental adviser and approval of the Graduate Affairs Office. A minimum of 27 units of work must be taken at Polytechnic.

In addition to the required courses, each master's program may include a comprehensive examination, or presentation of a seminar, or completion of a project or thesis.

Requirements for the Engineer Degree

Each candidate for the engineer degree must complete a minimum of 36 units of work beyond the master's degree. Part of this work will include a project or evidence of equivalent experience. A maximum of 12 units of project may be submitted toward fulfilling the degree requirements. All work for the engineer degree must be completed within five years after initiating work for this degree at Polytechnic. Any extension of this period requires recommendation of the departmental adviser and the approval of the Graduate Affairs Office.

All work for the engineer degree must be completed within five years after initiating work for this degree at Polytechnic. Any extension of this period requires recommendation of the departmental adviser and the approval of the Graduate Affairs Office.

The student must maintain an overall B average for all courses and for the project (if submitted in partial fulfillment of the requirements for the degree).
Requirements for the Doctor's Degree

Requirements for the doctor's degree are both qualitative and quantitative. Students will find that the formal requirements of residence, course units and dissertation provide a framework within which they are free to construct individual programs for creative learning.

Graduate students who wish to enter into a systematic program leading to the doctorate will confer with advisers in the department of major interest regarding selection of courses, major and minor fields of interest, formulation of guidance committees, and qualifying and language examinations. Students must satisfy the detailed requirements of the degree programs chosen.

Each candidate for the doctorate must complete three years of full-time study or its equivalent, namely, a minimum of 90 units of academic work beyond the bachelor's degree, including a minimum 24 units of dissertation research.

Once the student has started the dissertation, registration must be continuous until the dissertation has been completed and accepted, unless a leave of absence is granted.

Most departments have, in addition, specific course requirements. A minimum of 30 units, including the dissertation units, must be taken at Polytechnic. Each student must maintain an overall B average for all courses and for the dissertation units completed for the doctoral degree.

Foreign language requirements, if any, are determined by the individual departments.

Full-time students are required to complete all work for the doctorate within six years of initiation of graduate study at Polytechnic. For part-time students, the equivalent maximum time is 12 years. Any extension of these periods requires the recommendation of the student's Guidance Committee and the approval of the Graduate Affairs Office.

Graduate Certificate Programs

Polytechnic offers certificate programs in a number of specialized areas (see section "Curricula"). The "Application for Graduate Admission" must be completed and the applicant formally admitted to the certificate program. A student in a certificate program who subsequently decides to earn a graduate degree has to apply to do so. Application to transfer appropriate courses taken for the certificate to the degree program must be made.

To earn a certificate a minimum of 12 units must be taken at Polytechnic. A B, or better average in all courses is required. No course applied to a certificate may be applied to another certificate. The requirement for a certificate must be completed within three years.

Application for Degrees

Formal application for the award of the degree must be filed by graduate and undergraduate students. The filing dates for each semester are shown on the academic calendar in the Institute course bulletin. Students who do not file by the published deadline dates will become candidates for the next graduating class.

Applications for undergraduate and graduate degrees are available in the Office of Student Records and the Graduate Affairs Office. Degrees are conferred at the spring commencement. There are two graduation dates, one at the end of the fall and one at the end of the spring. Degree requirements are certified twice a year, at the end of fall and spring. There is a filing fee for the diploma which is payable at the time of filing in the Office of the Bursar. If award of the degree is delayed, the diploma fee is not recharge.

By vote of the faculty, degrees will not be awarded to members of the Institute teaching staff who hold the rank of assistant professor or higher.

Theses and Dissertations

Undergraduate Theses

The purpose of the thesis is to apply the knowledge gained in the field of the student's major interests and to familiarize the student with the methods of planning, conducting and reporting research.

Every student who plans to undertake a thesis project should report to the head of the department of major interest for choice of a thesis topic at least a year prior to graduation. The head of the department will approve the request and appoint a thesis adviser. The student should contact the thesis adviser immediately and register for thesis at the next registration period.

Thereafter, the student must register for thesis every fall and spring (summers, with special permission) until the thesis is completed and the final grade is entered on the student's permanent record.

The thesis may be a dissertation upon a subject included in the student's course of study, an account of original research, a report on a project or an original design accompanied by an explanatory statement. The regulations covering thesis registration and thesis format are available in departmental offices.

All theses and results obtained in connection therewith are the property of Polytechnic.

Graduate Research (Projects, Theses, Dissertations)

The investigations undertaken for graduate research have as their primary purpose the development of independent and creative thinking. Through them students are trained in analysis, research and synthesis, and contribute to science and engineering.

Research for an advanced degree shall embody
knowledge of the field of science or engineering chosen by the candidate, encompassing an understanding of basic principles, together with a commensurate acquaintance with current practices; the literature and the work of leaders in the field.

Research for the master’s and engineer degrees shall exhibit a thorough understanding of advanced scientific thought or ability to apply advanced principles constructively to engineering planning and design.

Research for the doctorate shall exhibit critical and constructive thought as well as ability to use the techniques necessary in the exploration and development of new areas in science or new applications in engineering.

All research should be characterized by accuracy of observation and measurement; by thoroughness of analysis and synthesis; and by clarity and completeness in presentation. The conclusions presented must be supported by adequate studies and investigations and supplemented by a complete bibliography.

Registration for Theses and Dissertations

After a project or thesis adviser or guidance committee has been appointed, the candidate should register for a number of units to realistically reflect the amount of time the candidate expects to devote to this research. Registration must be continuous (every fall and spring, summers with special permission) until an adequate research project and an acceptable thesis have been completed and the required oral examination has been passed. The registration pattern may not be interrupted except with the permission of the Graduate Affairs Office until a grade is entered on the permanent record. If at the end of a semester the work covered by any unit of registration is deemed unsatisfactory by the adviser, registration for the same unit may be required; such reregistration will oblige the student for full tuition and laboratory fees. Registration for the last unit is required until a permanent grade is submitted to the Office of Student Records.

Manuscript Presentation

The research is to be presented to the appointed guidance committee by the candidate in final manuscript form for official acceptance on or before the Monday seven weeks before commencement. Draft copies of research manuscripts toward advanced degrees in chemistry and in electrical engineering are required no later than nine weeks before commencement; in chemistry, four typewritten copies are required; in electrical engineering, a single copy.

Research Submission

The format of the bound dissertation is prescribed, and a brochure entitled "Regulations on Format, Duplication and Publication of Project Report, Thesis, and Dissertations" is available from the Graduate Affairs Office and from the various departmental secretaries. Some of the regulations are summarized below.

Master’s or engineer degree candidates are to submit four final bound copies of their research, and doctoral candidates must submit five final copies, of which one copy is to be unbound for microfilming, while the four others are to be bound. Duplication processes of high quality are acceptable. In addition, each doctoral candidate is required to submit two copies of an abstract of not more than 350 words suitable for publication in "Dissertation Abstracts."

The four finished copies are to be submitted to the department for signature and presented to the Graduate Affairs Office before noon on the first Friday in December (for fall degrees) or the first Friday in May (for spring degrees). At the same time, doctoral candidates must submit the unbound copy in a labeled envelope and the two copies of the abstract to the Graduate Affairs Office. The original copy is kept permanently in Spicer Library.

Publication

Doctoral dissertations will be microfilmed at University Microfilms, Ann Arbor, Michigan, and abstracts of them will be published in the journal "Dissertation Abstracts."

The cost of this service will be charged to the student. Copies of these microfilms may then be purchased from University Microfilms by any interested person.

The faculty regards publication of the major content of a doctoral dissertation in a recognized scientific journal as a necessary final step if the work performed is to achieve maximum usefulness. A deposit is assessed against each doctoral candidate to insure the necessary efforts will be made to secure such publication. This deposit will be returned if evidence of publication (in the form of three reprints of the article judged satisfactory by the department) is deposited with the Graduate Affairs Office within six years of the awarding of the degree. To be satisfactory, the article must indicate, by footnote or otherwise, its basis in a Polytechnic dissertation.
PRIZES AND AWARDS GIVEN AT GRADUATION

Aerodynamics Laboratories Award
American Institute of Aeronautics and Astronautics Award
American Institute of Chemists Award
American Society of Mechanical Engineers Award
American Statistical Association Award
John W. Andrews Placement Award
Richard W. Beek Award
John R. Bradley Alumni Award of Service
Daughters of the American Revolution Award
Cow-Jones Wall Street Journal Student Achievement Award
Mitchell Fan Award
Simeon Gang Award
Margaret Goodstone Memorial Fund Award
Harold Hertzberg Award
James H. Hughes, Jr. Award
Institute of Electrical and Electronics Engineers Award
Noah A. Kahn A.S.T.M. Committee E-7 Award
Raymond E. Kirk Award
Eugene R. Kulka Award (Eta Kappa Nu)

Eugene R. Kulka Award (Tau Beta Pi)
George C. Marshall ROTC Award
Mermaid Club Awards
New York Metropolitan Section of the American Nuclear Society Award
Omega Chi Epsilon Award
Outstanding Student Award
David B. Porter Award
Allan Raymond Prize
Robert Ridgway Student Chapter Prize
Myron M. Rosenthal Prize
Myron M. Rosenthal Scholarship Fund Award
George D. Schaefer Award
Seymour Shapiro Award
William H. Searight Memorial Award
Sigma Xi Senior Research Award
Joshua Sills Award
Albert E. Sobel Prize
Theodore Clinton Tow Award
ACADEMIC POLICIES

THE FAMILY RIGHTS AND PRIVACY ACT
(Buckley Amendment)

Description of the Act: The Family Rights and Privacy Act of 1974 grants to students certain rights, privileges and protections relative to individually identifiable student educational records which are maintained by the Institute. Specifically: (1) Your educational records (with the exception of directory information) will be released to third parties outside the Institute only with your written consent. (2) You have the right to inspect your own individually identifiable educational records. (3) You have the right to have reviewed the information contained in your individually identifiable educational record.

The Family Educational Rights and Privacy Act permits the release of directory type information to third parties outside the Institute without your written consent provided you have been given the opportunity to withhold such disclosure. The Institute reserves the right to disclose, at its discretion, the following categories of personally identifiable directory information: name, class year, major field, dates of attendance at Polytechnic Institute of New York, degree. Currently registered undergraduate and graduate students may withhold directory information by requesting this in writing to the Office of Student Records each semester.

Additionally, Long Island campus students names, addresses and telephone numbers may be released to other students for the purpose of arranging car pools. If you wish this information to be withheld, you must notify the Office of Student Records at the Long Island campus.

CLASS STANDING

Undergraduates. Students are classified at the end of each semester by the Office of Student Records on the basis of earned and/or approved transfer credits as of September 1 as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshmen</td>
<td>1-27 credits</td>
</tr>
<tr>
<td>Sophomores</td>
<td>28 credits plus</td>
</tr>
<tr>
<td>Juniors</td>
<td>62 credits plus</td>
</tr>
<tr>
<td>Seniors</td>
<td>95 credits plus</td>
</tr>
</tbody>
</table>

CREDITS PERMITTED

Undergraduate

Full-time. A program of 12 credits or more categorizes a student as a full-time undergraduate student. The maximum course load for full-time undergraduate students is 19 credits. Students in special situations (such as graduating seniors or ROTC cadets) must receive permission from the designated person in their major academic department for any program above 19 credits. Students taking an excess of 20 credits will be charged the per credit rate for additional credits or half credits.

Part-time. Any student registered for less than 12 credit hours per semester (except summer) is considered a part-time student. Part-time students do not qualify for most financial assistance programs.

Summer session. A student may register for seven credits for each six-week summer term and for no more than 14 credits for the combined 12-week summer session. Registration for six credits for a given summer term is considered full-time status, particularly for financial aid purposes.

Graduate

Full-time. Registration for 12 units or more categorizes a graduate student as full-time. The maximum course load per semester is 18 units. Students who desire to register for more than 18 units must obtain permission from their department heads and the Office of Graduate Affairs prior to registration. Students who register for more than 20 units will be subject to an additional tuition fee based on the per-credit tuition for all units in excess of 20.

Part-time. Registration for less than 12 units comprises part-time status in a graduate program.

GENERAL INFORMATION

COURSE WITHDRAWAL

Students may withdraw from a course or courses without academic penalty through the 10th week of the semester according to the published schedule. Students who fail to withdraw by the deadline will automatically receive a grade of W. Once entered on the student's record, the grade of W cannot be changed to any other grade. A grade of F will be recorded for any student who ceases to attend a course without notifying the Office of Student Records in writing.

TOTAL WITHDRAWAL FROM THE INSTITUTE

Students having to withdraw completely from the semester in which they are registered must notify the dean of student life or the Office of Graduate Affairs. No withdrawal is official unless a written form is approved and submitted to the Office of Student Records. Mere absence from class does not constitute official withdrawal. There is no charge for a complete withdrawal from all classes.
PASS/FAIL OPTION

The purpose of the pass/fail option is to allow and, where possible, encourage qualified students to take difficult and adventurous courses without undue fear of jeopardizing their grade point average. Accordingly, students who have cumulative grade point averages of 3.2 and above and 30 or more earned credits at Polytechnic may elect, during the first five days of the semester, to take one elective course on a pass/fail basis, with the major advisor's approval. No more than six courses in all may be chosen pass/fail by an undergraduate student. The student choosing this option shall not inform the instructor. At the end of the semester, the instructor will submit a letter grade which the registrar will automatically change to a P or F. A request for a letter grade other than P or F will not be honored once the pass/fail option has been chosen.

No course required by the student's major department or by the Institute may be taken on a pass/fail basis (e.g., SS 104, HU 101, MA 101, MA 102).

AUDITING COURSES (Graduate Students)

Students may choose the option of auditing a course instead of receiving credit and a grade for it. Regular tuition is charged, and the course is treated as part of a full-time load. The AU notation appears on the permanent record.

Interested graduate students should see their advisers and must notify the Office of Student Records office within the first six weeks of the semester of their selection of audit status. Under no circumstances may an audit status be changed to credit status once elected.

CREDIT BY EXAMINATION (Undergraduate Students)

In order that capable undergraduate students may move more rapidly into graduate work, comprehensive examinations are available to establish credit in courses required for the baccalaureate degree to a maximum of 18 credits. Approval of the department of major study, the department giving each course and the Dean of Student Life is required.

Students may not take examinations for credit for any course for which they have registered at the Institute.

A specified fee is paid to the bursar in advance of each examination. Credit for a subject not previously studied at Polytechnic is earned by achieving a grade of B+ or better in the examination. The grade is not posted to the permanent record.

When validation of transfer credit is the purpose of this examination, the passing grade is set by the department administering the test. In the area of foreign languages, those presenting their native tongue or the language in which they were schooled are excluded from credit by examination tests in lower-level language courses (i.e., courses for the first four semesters of that language).

VALIDATION CREDIT (Graduate Students)

When it is unclear whether a course taken outside Polytechnic is suitable for transfer credit, a student may qualify for transfer credit by passing a validation examination. Application for the validation examination is made through the Graduate Affairs Office to the appropriate department.

The sum of validation credits and transfer credits is limited to a maximum of nine credits for the master's degree.

TRANSCRIPTS

The Institute complies with the provisions of Public Law 93-380 “The Family Rights and Privacy Act” and will issue personally identifiable information only upon written authorization from the student.

Official transcripts of the scholastic record of any student or graduate will be issued only at the student’s written request or upon submission of a signed release. Official transcripts will be sent directly to the school to which the student is transferring or to any other proper authorized party. In no case, however, will a student receive an official copy of his or her own transcript. Unofficial student transcripts are available to any student upon request in writing. The first transcript will be issued without charge.

The school reserves the right to withhold the issuance of a student’s transcript because of failure to meet financial indebtedness to the Institute.

COMPUTATION OF GRADE-POINT AVERAGE

Undergraduate Grading

The weighted grade-point average of an undergraduate student is determined at the Office of Student Records on the basis of the following numerical values assigned to the letter grades:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Point Value</th>
<th>Grade</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0</td>
<td>C+</td>
<td>2.3</td>
</tr>
<tr>
<td>A−</td>
<td>3.7</td>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>B+</td>
<td>3.3</td>
<td>C−</td>
<td>1.7</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
<td>D+</td>
<td>1.3</td>
</tr>
<tr>
<td>B−</td>
<td>2.7</td>
<td>D</td>
<td>1.0</td>
</tr>
</tbody>
</table>

A grade of F equals 0.

In the computation of grade-point averages, courses are not considered for which the notation W or I is entered upon student records, nor where S, U or P has been assigned.

The grade-point average is computed by multiplying the number corresponding to the grade in each course by the hours of credit for the course, adding these products for the courses taken and then dividing this sum by the total number of hours represented by the courses considered.
**Course Repeats**

If an undergraduate student takes a course two or more times, only the second and subsequent grades will count toward the student's grade-point average, provided the second taking of the course is completed within one year of the first. If the course is not offered within one year, it must be taken at the time of its first offering thereafter. This applies whatever the first and second grades.

**Graduate Grading**

For the purposes of computing graduate grade-point averages, the following schedule will be used:

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Grade-Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
</tr>
<tr>
<td>F</td>
<td>0.0</td>
</tr>
</tbody>
</table>

When a student repeats a course, the lowest grade will not count towards the grade point average. All other grades in a repeated course will be included in the grade point average.

The AU notation is used for audited courses. Notations AU, W, and I are not counted in the grade-point average. S or U grades are used for continuing research registration until the work is completed at which time the earned letter grade is entered on the student's permanent record. The grade-point average is not shown on the graduate permanent record.

**INCOMPLETE GRADES**

When for valid reasons, such as illness or some critical emergency, a student is unable to complete the course work at the usual time, the instructor may give a grade of I. The duration of this temporary grade is determined by the instructor and it usually shall not extend beyond the end of the intersession.

The I grade lapses into a grade of F if the student fails to complete the course work within one year. If a student re-registers for a course in which an I grade was given, the I grade lapses to an F.

All I grades must be converted prior to graduation.

**CHANGE OF DEPARTMENT**

Even though students voluntarily indicate on their applications their field of special interest, it is expected and understood that, with the passage of time, some will wish to make changes in department. Final approval for such action by undergraduates must be obtained from the adviser of the new department.

Graduate students must apply for a change of department through the Graduate Affairs Office. Such applications will require the approval of the department. Students changing departments at the graduate level may be required to satisfy new conditions consistent with the requirements for the degree.

**LEAVE OF ABSENCE**

**Undergraduate**

A student wishing a leave of absence should discuss this with the dean of student life. A student desiring to re-enter after a period of absence may submit a request for readmittance by filing an application with the Office of Admissions.

**Graduate**

Part-time graduate students, who last attended Polytechnic within a three-year period prior to the semester for which they are seeking readmission, need no formal readmission. However, in order to receive registration material, they should notify the Office of Student Records. Full-time students who desire to interrupt their studies may request a leave of absence for a specified period usually not exceeding one year. Such a request, when approved by the Graduate Affairs Office, will constitute assurance of readmission to a degree program. Forms for requesting a leave of absence are available in the Office of Graduate Affairs.

Once a graduate student has started the dissertation, registration must be continuous, and a leave of absence is required for semesters in which a student will not be registering for research credits. Students failing to obtain a leave of absence who wish to be readmitted may be required to retroactively register for those semesters not attended.

**CONCURRENT ATTENDANCE**

Undergraduate students enrolled at Polytechnic may not enroll in another institution at the same time for academic credit unless they have written approval from their academic adviser and the department head(s) of the course(s) in which they wish to receive credit. Such permission must be obtained in advance of registration at the other school, and the combined number of credits may not exceed the total permissible at Polytechnic.

**ACADEMIC STANDING**

In order to remain in good standing, an undergraduate student must maintain term and cumulative grade-point averages of 2.0 or greater. In addition, he or she must successfully complete a minimum number of credits during each term of full-time study. In this instance, "term" is used to refer to fall and spring sessions. "Term," in the case of part-time students, indicates the points at which 12 or more credits are undertaken. Thus, the first term of study ends where 12 credits are accumulated; the second is calculated from that time onward until 24 credits are accumulated. According to these term equivalents, grade-point requirements for part-time students follow those for full-time students.

The minimum number of cumulative credits to be achieved by the close of each term of full-time study appear in Table I.
In calculating the number of credits successfully completed:
1. Credits undertaken for which the grade of F is earned count in the calculation of total credits of enrollment. However, they do not figure into the number of credits successfully completed.
2. Credits originally bearing the grade of F and repeated within one academic year will be recalculted with the second grade earned, thus potentially entering into the number of credits successfully completed during the term in which it is repeated.
3. Credits assigned the grade of W do not appear in the calculation of credits undertaken, earned or successfully completed.
4. Credit with the grade of incomplete will be counted toward successful enrollment for one term. At the end of that time any grade of I or W that has not been changed by the professor of record will go to the grade of W or F, respectively, and be deleted from the number of credits successfully completed.
5. Transfer students will enter the standard as calculated from the point at which transfer credits place them. It is likely that they will fall between the credit grade-point minimums in the same way as students pursuing 128 and 128 credit curricula and four year graduates.

A second requisite for enrollment is the maintenance of a grade-point average of 2.0 or above, or performance approaching 2.0 in a steady and realistic fashion. The grade-point average is calculated by dividing the number of quality points achieved by the total number of credits undertaken. Accordingly, all credits assigned a latter grade, whether successfully or unsuccessfully completed, are used in establishing the grade-point average. Table II contains the absolute minimum cumulative grade-point average to be achieved by the close of term of full-time enrollment.

TABLE I

<table>
<thead>
<tr>
<th>Term</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
<th>IX</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum credits successfully completed</td>
<td>18</td>
<td>30</td>
<td>44</td>
<td>58</td>
<td>73</td>
<td>88</td>
<td>104</td>
<td>120</td>
<td>136</td>
<td></td>
</tr>
</tbody>
</table>

ACADEMIC MONITORING

Undergraduate academic performance is monitored at the end of each semester by the Dean of Student Life in consultation with the departments.

DEAN'S LIST

Undergraduate students who achieve a grade-point average of 3.0 or better, with no failures, are commended by the Dean of Student Life and placed on the honors list. This list will be posted semi-annually for full-time and annually for part-time students. Only those who complete 12 semester hours or more of study during the interval, and who have an overall cumulative grade-point average of 3.0 or better, are eligible for the Dean's List. Students who include project and thesis courses in their 12-credit-or-more programs are also eligible for the Dean's List; provided these courses comprise one-half or less of the credit load for the semester and all the aforementioned requirements are met. The Dean's List notation appears on the permanent record.

PROBATION

Students whose grade-point average approaches 2.0 are warned of potential difficulty and are urged to take whatever measures are necessary to maintain good standing.

A student is placed on probation when the semester and/or cumulative grade-point average falls below 2.0. The status of continued probation is assigned when the grade-point average(s) remain below 2.0 for more than one term. When the grade-point average and the number of credits successfully completed approaches the minimum level of satisfactory progress, a student is required to seek the permission of the Dean of Student Life in order to register. The latter situation is one of compulsory guidance, and is noted by an "X" in the upper right corner of the registration pass.

Students on probation or continued probation should limit their co-curricular activity. They may participate in advance registration, but are limited to fifteen (15) credits. If their semester performance returns them to good standing, they may add credits during on-site registration, with the approval of their academic adviser and the Dean of Student Life. Students who must have permission to register may not participate in advance registration. They will not be assessed a late fee at on-site registration. Students in this situation should limit their program to no more than fifteen (15) credits.

DISQUALIFICATION

The Committee of Standing, comprised of the Dean of Student Life and representatives of the student's major department, shall jointly disqualify from the Institute any student whose cumulative average or number of credits successfully completed falls below the appropriate minimum shown in Tables I and II.

Additionally, a student's major department may disqualify a student at or above the minimal listed, if it is indicated that further continued performance will not lead to successful completion of degree requirements. Unless accepted into another department, a student so disqualified will not be permitted to reapply to the Institute for at least one academic year.

Extenuating circumstances, such as medical and serious personal disorders, must be documented and can lead to the waiver of these criteria for one term. Performance in the subsequent term must meet the minimum standard. Such reckoning must be made in concert with the student's major department and the Dean of Student Life.
OFFICE OF STUDENT LIFE

The Office of Student Life is responsible for the operation and maintenance of the Institute's community- and student-oriented programs and services. More specifically, the function of the office is to help students obtain the maximum benefit from their college training—academically, culturally and socially. To achieve this objective, the office supplements and reinforces the educational program by:

- Providing services to guide the student in obtaining the most satisfactory results in scholarship and personal adjustment
- Giving assistance to the student in matters such as health insurance, housing and community resources
- Coordinating the cocurricular student activity groups and organizations
- Representing student interests in the decision-making processes of the Institute
- Keeping the student aware of the rules and policies of the Institute
- Administering the academic and disciplinary policies of the Institute

STUDENT RETENTION

As required by the New York State Education Department, Higher Education Data System, the Polytechnic conducts a yearly cohort survival analysis. This study is designed to collect data for a group or cohort of first-time (never attended college before), full-time freshmen who enter the Institute. The data measures retention patterns, and indicates the amount of time needed to complete an undergraduate degree at the Polytechnic.

The initial cohort for the fall 1981 study was the group of first-time, full-time students who entered the Institute as freshmen in the fall of 1976.

Of that entering class, 38.6% received their Bachelor of Science degree within four years; 53.7% graduated within five years; and 57.3% completed their degree within six years of their first term. A small group (2.3%) were granted degrees after three years of study.

UNDERGRADUATE ORIENTATION

An orientation program is planned for the beginning of each semester. At this time, incoming students and their parents are introduced to the academic and social environments of Polytechnic Institute. Informative sessions, advisement and activities related to student life are offered. The purpose of this program is to welcome new students and assist them in making the transition from their former academic environment to that of Polytechnic as comfortable as possible.

UNDERGRADUATE ADVISERS

Freshmen are assigned an adviser in their major department who is available for individual counseling on all academic and related matters. Faculty members also serve as advisers to the undergraduate extracurricular activities.

GRADUATE ADVISERS

Representatives of the various departments are assigned as advisers to assist graduate students in the selection of courses to meet their individual needs, to aid them in planning a program for an advanced degree and to guide them in their professional advancement.

COUNSELING SERVICES

The Institute offers no psychological services. Often students require counseling in dealing with matters concerning family problems, study habits or adjustment problems. Referral for psychological counseling is offered by the Office of Student Life at no charge. There may be a fee for services by these agencies, on a sliding scale based on income and expenses.

OFFICE OF SPECIAL SERVICES

Tutoring and counseling services are offered through Polytechnic's Office of Special Services. If a student is in need of academic assistance, the Office of Special Services provides tutoring on an individual or group basis. Qualified upperclass students serve as mathematics, physics, computer science and chemistry tutors.

Interested students can also take advantage of workshops in note-taking, time management and test-taking. These academic-related skills assist students in successfully mastering the technical curriculum at Polytechnic.

In addition to academic guidance, the Special Services staff provides vocational and personal counseling. On-site visits and plant tours are arranged to help students explore the various opportunities available to them when they leave school.

Special Services coordinates a summer program designed to assist pre-freshmen with deficient academic backgrounds. Through summer courses in mathematics, English and study skills, incoming students are able to strengthen their abilities and enter Polytechnic in the fall ready to meet the academic challenge.

Addressing the varied needs of the Polytechnic student is the primary goal of the Special Services Office. Because the Office of Special Services is sponsored by a grant from the U.S. Department of Education, all
students requesting assistance must first meet the federal eligibility guidelines. For those who qualify, all tutorial, educative and counseling support services are provided free-of-charge.

TUTORING PROGRAM
(Freshmen Learning Center)

Freshmen showing failure or low grades at midterm are notified that tutoring would be helpful. All students can arrange for tutoring on a one-to-one basis if they have failed a course, or if there is a drop in grades during the semester. There is a prearranged schedule for the student and tutor which stands for the entire semester, which generally lasts for one hour a week per course. Students missing three sessions will be dropped from the program. Improvement is monitored by evaluating the grades of the student when entering the program versus the grades while being tutored. The tutors are seniors and juniors on the dean’s list who have been carefully screened by the faculty and the counseling staff. There is no charge for this service.

INTERNATIONAL STUDENTS

The Polytechnic Institute of New York has enrolled international students in both graduate and undergraduate studies for many years. Visa holding students make up approximately 12% of the Polytechnic population. They are an integral part of Polytechnic. Faculty and administrators are sensitive to the needs of international students, and strive to meet those needs. Services for international students are located in the Office of Student Life, and coordinated by the Director of International Student Services. Information regarding immigration compliance, housing, health insurance, special events and referrals are available through the International Student Office in the Student Center. That office should be contacted immediately upon arrival for further information, consult those sections dealing with graduate and undergraduate admissions.

HANDICAPPED STUDENTS

The Institute makes every effort to provide for full program accessibility and barrier-free restrictions so that handicapped individuals may fully participate in the life of the college community.


CAREER SERVICES

The placement service for students functions as part of the educational system at Polytechnic. It is a student-oriented service committed to the principles of individual responsibility, free choice and human development. Specifically, Career Services believes that individuals must assume the responsibility for deciding what, how, when and where they will provide for their future needs.

Accordingly, the primary function of Career Services is to help students learn how to locate suitable positions, decide whether to work or pursue graduate studies, or to make other decisions concerning post-graduate plans. This service continues after graduation, and all alumni are encouraged to contact Career Services whenever they need assistance in planning or making a career or job change.

Each year, Career Services hosts several hundred recruiters from industry, business and government for the purpose of interviewing students for employment opportunities. Additional functions, such as Career Days and Career Seminars, are also held. All students are encouraged to become acquainted with the staff of Career Services early and to fully utilize its services.

Placement of Graduates

The Career Services office assumes those responsibilities connected with career orientation and the full-time and part-time employment needs of Polytechnic students and alumni. It serves as the focal point for the continuing and expanding relationship between the institute, business and industry. Demand for our graduating students and alumni is high, and is complemented by the number of individuals seeking placement services in order to secure full-time career positions. The growth and success of the Career Services office is indicated in the chart below:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of firms recruiting</td>
<td>129</td>
<td>176</td>
<td>211</td>
<td>235</td>
<td>267</td>
</tr>
<tr>
<td>Students seeking employment</td>
<td>370</td>
<td>343</td>
<td>530</td>
<td>526</td>
<td>550</td>
</tr>
<tr>
<td>Interviews conducted on campus</td>
<td>2,952</td>
<td>4,155</td>
<td>5,764</td>
<td>5,500</td>
<td>5,580</td>
</tr>
<tr>
<td>Employment rate</td>
<td>93.4%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
</tbody>
</table>

ACCIDENT AND HEALTH SERVICES

Presently, all full-time undergraduates and graduates are covered by accident insurance. Emergency treatment is provided at a nearby hospital, and the Institute arranges for escorts to the hospital in case of an accident or health emergency occurring on campus. Health insurance is recommended for all full-time students. For a specified fee, a student can be covered for health and hospitalization. Foreign students and residence hall students are required to enroll in the Polytechnic policy group or show comparable coverage from another source.

STUDENT ACTIVITIES

Student activities play an important role in the development of the leadership and organization abilities of an individual. The Institute encourages involvement in student activities as a significant dimension of the educational process.
STUDENT CENTER

The focus of all student activities on both campuses is the Student Center. On the Brooklyn campus, the building contains a game room with pinball and video games, a cafeteria that is used for programs, student organization offices, lounge space, a TV room, and administrative offices of some student life staff.

On the Farmingdale campus, Grumman Hall, the Student Center, houses a game room which includes video and pinball games, pool tables and ping-pong tables, the bookstore, a darkroom, student organization offices, and a pub.

There are approximately 70 student organizations. Each group is responsible for fulfilling the purpose of the organization as set forth in a constitution. Those documents are filed with the Student Council when an organization is recognized.

STUDENT GOVERNMENT

The Student Government is the student voice at the Institute. The members of the Student Government are elected during campus-wide elections held every year. It is responsible for the administering of the student fee, social and cultural programming, and other co-curricular events.

PUBLICATIONS

A number of student-run publications exist at the Institute. The Polywog is the yearbook of the Institute. It is a yearly publication which serves as a remembrance of the time spent here by students. The Reporter is the campus newspaper. The Reporter provides the student with the opportunity to produce a newspaper from start to finish. It also supplies both campuses with a source of campus news. The Polytechnic Engineer is a magazine devoted to technical and engineering topics. The Phoenix is the student body’s literary publication.

RADIO STATION

WPIV is the student-operated radio station located in the Brooklyn Student Center. The station offers a cross section of musical interests with student disc jockeys presenting shows. A record library and production facilities are available.

ATHLETICS

For students who seek intercollegiate competition, Polytechnic fields teams in which junior varsity and varsity competition is actively pursued: baseball, basketball, wrestling, rifle, tennis, swimming, cross-country, fencing and soccer.

Polytechnic also encourages intramural competition in touch football, volleyball, basketball, hockey, tennis, handball, softball and badminton.

PROFESSIONAL AND DEPARTMENTAL SOCIETIES

Professional and technical societies are established in conjunction with the various departments in order to enhance the curricula at Polytechnic. The student chapters are branches of national parent organizations. In their chapter meetings, student members hear distinguished guest speakers, plan field trips and read professional papers. There are also four unaffiliated professional societies at Polytechnic.

Fraternities

Six national fraternities are represented at Polytechnic. Most own or rent property in the Brooklyn area, with three offering live-in accommodations. The social fraternities contribute to the student community of Polytechnic. Not only do they administer an impressive array of social functions for their own members, but they also serve the student body in many activities. These include the organization of blood donation drives, dances, an annual charity drive and handball, basketball and bowling tournaments. On the Farmingdale campus, one national fraternity exists. This group is very actively involved in the social and community life of the campus.

Clubs

At Polytechnic, there are clubs to suit every interest, whether intellectual, religious, musical, cultural or athletic. The range is quite broad. Many have had a long and distinguished history. Some of these are the Chess Club, Radio Club, Railroad Club and the Pershing Rifle Drill Team.

Honor Societies

On the basis of their superior record of academic and cocurricular achievement, students are elected during their junior and senior years to one of Polytechnic’s chapters of the national honorary fraternities. Closely allied to the professional or technical societies, these honorary societies encourage and recognize outstanding scholarship and leadership.

RECOGNIZED OCOCURRICULAR ORGANIZATIONS

Professional Societies
American Chemical Society
American Institute of Aeronautics and Astronautics
American Institute of Chemical Engineers*
American Institute of Industrial Engineers
American Institute of Mining and Metallurgical Engineers
American Institute of Physics
American Nuclear Society
American Society of Civil Engineers*
American Society of Mechanical Engineers*
American Society for Metals
Association of Computing Machinery
Institute of Electrical and Electronic Engineers*
Nuclear Engineering Society
Operations Research and Systems Analysis Society
Operations Research Society of America
Physics, Math Society
Pre-Med Society
Society of American Military Engineers
Society of Automotive Engineers*
Society of Experimental Stress Analysis
Society of Physics Students
Society of Women Engineers*
Space Technology and Resources Association

**Student Organizations**

Association of Latin American Students
Astronomical Society
Capers
Chess Club
Chinese Students Association
Christian Fellowship
Demokritos
Dungeons and Dragons Club†
International Students Association
Iranian Student Association
Jewish Student Union
Karate Club†
Korean Students Association
NARTU
National Association of Black Engineers
Pershing Rifles
Photography Club
Radio Club*†
Resident Student Organization†
Sappors
Society of Chinese Engineers
Stage Band†
Student Government Organization†

**Fraternities**

Alpha Pi Delta
Alpha Phi Omega
Lambda Chi Alpha
Pi Kappa Phi
Tau Delta Phi*†
Tau Epsilon Phi†

**Honor Societies**

Alpha Pi, industrial engineering
Alpha Sigma Mu, metallurgy
Chi Epsilon, civil engineering
Eta Kappa Nu, electrical engineering*†
Omega Chi Epsilon, chemical engineering
Omega Rho, operations research
Pi Lambda Upsilon, chemistry, chemical, and metallurgical engineering
Pi Mu Epsilon, mathematics
Pi Tau Sigma, mechanical engineering
Scabbard and Blade, Military Science
Sigma Gamma Tau, aerospace engineering
Sigma Pi Sigma, physics
Sigma Xi, research*†
Tau Beta Pi, engineering*†

**HOUSING**

Residence Hall life at Polytechnic is designed to provide the student with a comfortable place in which to live, grow and complete his/her out-of-classroom education. There is a coordinator of residence life who works with resident assistants on the Brooklyn campus and directly participates in implementing these goals at the Long Island Center.

As a Polytechnic student, you will use the Residence Hall for studying, relaxing, sleeping and making friends. If you take advantage of the Residence Hall programs, you can enrich your college years with a variety of experiences. You can take part in tournaments, Resident Students Organization functions, sports and many other activities.

Resident students on the Brooklyn campus are housed on three floors of the Richard L. Connolly Residence Hall of Long Island University, just four blocks from Polytechnic. Residents are assigned to double rooms. There are no facilities for children or married couples, but married couples who are both students of Polytechnic can be housed together in the same room. There are no cooking facilities but there is an optional meal plan available.

The Residence Hall on the Long Island campus houses 50 students. Each suite contains four private bedrooms, a common suite room complete with kitchenette, a shower room and a bathroom. Facilities include a recreation room with television, vending machines, video games and a laundry room. There are no facilities for children or married couples. Off-campus housing is available in the surrounding area.

Inquiries about housing should be made to the Office of Student Life on respective campuses.

In order to assure tranquility and appropriate living environment, all residents are expected to respect each other’s privacy and rights. Inappropriate behavior will be addressed through the following sanctions:

1. **Verbal Warning**
   A verbal warning will be made to the student by the Coordinator of Resident Life discussing the incident.

2. **Written Warning**
   An official written warning will be sent to the student and will be discussed with the Coordinator of Resident Life. The student is told that further violations will result in probationary action. A copy of the warning is put in the student’s file for one year.

3. **Probation**
   A student will be put on dormitory probation by the Coordinator of Resident Life for a specified length of time. If involved in any additional incidents, this may result in possible removal from the dormitory. A copy of the probationary letter will be put into the student’s file for one year.

4. **Suspension/Removal**
   The Coordinator of Resident Life in consultation with the Dean of Student Life will convene the Student Affairs Committee of the Faculty. The action of the suspension/removal will be discussed with the length of time of suspension or permanent removal determined by the Committee.

* Represented on Brooklyn and Farmingdale campuses
† Represented on the Farmingdale campus only
CODE OF CONDUCT

The Polytechnic Institute of New York draws together a diverse population in pursuit of honest inquiry and academic excellence. The processes of education and human interchange that ensue are grounded in academic freedom and mutual respect. The rights and responsibilities contained in municipal, state and federal statutes are provided and expected from all members of the Polytechnic community. The Institute reserves the right to note, investigate and take appropriate steps as described below.

ACADEMIC INTEGRITY

The faculty assumes that themes, term papers, results of laboratory experiments and examinations submitted by students represent their own work. The presentation for academic credit of the same work in more than one course is prohibited unless a joint project receives the expressed and prior permission of the instructors involved. The following explanations are intended to clarify this statement for all students.

Written Work

All sources of assistance, published or unpublished, are to be acknowledged in every piece of writing.

Examinations

A student using or receiving unauthorized assistance during an examination, as from notes or other students, is in violation of academic regulation and is subject to academic discipline, including forfeiture of credit for the course, probation and dismissal from Polytechnic Institute.

Laboratory Experiments

Although a student may be permitted or required to cooperate with one or more fellow students in a laboratory experiment, many experiments are to be done by the students independently, and all require some independent work. For a student to submit the results of another’s work as the student’s own or to accept unauthorized help in an experiment constitutes academic dishonesty.

I. RULES OF CONDUCT

A. All members of the Institute community—students, student organizations, faculty members and members of the staff—shall comply with city, state and federal laws and ordinances affecting the maintenance of order on Institute premises.

1. Conduct that is violative of such laws and ordinances occurring on Institute premises may be subject to Institute discipline and public sanctions as circumstances may warrant or dictate.

2. Conduct that is in violation of such laws and ordinances occurring off Institute premises will ordinarily not be subject to Institute discipline, unless such conduct:

   a. seriously affects the interests of the Institute or the position of the member within the Institute community, or
   b. occurs in close proximity to Institute premises and is connected with violative conduct on Institute premises.

B. All members of the Institute community are prohibited from engaging in conduct leading to or resulting in any of the following:

1. Interference with or disruption of the regular operations and activities of the Institute.

2. Denial of, or unreasonable interference with the rights of others—including persons not members of the Institute community who are present as invitees or licensees—on Institute premises. These rights include the right of academic freedom as well as constitutionally protected rights.

3. Injury to Institute property, real or personal

4. Unauthorized access to or occupation of nonpublic areas on Institute premises, including but not limited to classrooms, seminar rooms, laboratories, libraries, faculty and administrative offices, auditoriums, and recreational facilities.

5. Unauthorized access to or use of personal property, including files and records.

C. Visitors, including invitees and licensees, shall at all times conduct themselves in a manner that is consistent with the maintenance of order on Institute premises, and their privilege to remain on Institute premises shall terminate upon breach of this regulation. The Institute in addition reserves the right at its discretion to withdraw at any time the privilege of an invitee or licensee to be on Institute premises. A trespasser has no privilege of any kind to be on Institute property but is nevertheless subject to these regulations governing the maintenance order.

D. Nothing contained in these rules is intended nor shall it be construed to limit or restrict the freedom of speech or peaceful assembly.

II. PROGRAM OF ENFORCEMENT

A. Visitors (invitees, licensees and trespassers). When administrative officers or members of the protection service of the Institute in their discretion determine that the
privilege of an invitee or licensee to be on Institute premises should be withdrawn, they shall ask the invitee or licensee to leave the premises, and the invitation or license shall here be terminated. If any person, whether initially a trespasser, licensee or invitee, fails to leave Institute premises promptly upon request, the Institute will use all reasonable means, including calling for assistance of the police, to effect removal.

B. Disciplinary Action. A member of the Institute community who is charged with a violation of the Institute rules set forth in Section I above shall be subject to appropriate disciplinary action as follows:

1. Students
   a. Disciplinary action shall be carried out by the Student Affairs Committee of the Faculty and the Office of the Dean of Student Life. Academic performance falls within the purview of the instructor who may seek the assistance of the department head. In instances of broader consideration, the services of the dean of student life are requested. That person will contact all parties involved, collect facts and request the advice of the monitoring bodies within the academic community. In order to initiate this process written complaints are submitted to the dean of student life.

   Matters of sufficient gravity that affect the general operation and policies of the Institute will be addressed at an administrative hearing. At that time a person may introduce personally relevant information in support of a particular position. The person may also have an adviser present. Such deliberations will be carried out by the Student Affairs Committee. The recommendation of that body may be appealed to the Provost.

2. Faculty Members
   a. When a faculty member is charged with a violation of these rules, an effort shall be made to resolve the matter informally under the direction of the dean of the respective division at the departmental level or with a committee of the faculty of that division.

   b. When the matter cannot be resolved as provided in the preceding paragraph, disciplinary action shall proceed as follows:

      i. If the faculty member charged with a violation has permanent or continuous tenure, the Rules of Tenure in the Code of Practice shall apply.

      ii. If the faculty member does not have continuous or permanent tenure, this case shall be referred to a special committee of the faculty designated for that purpose. The special committee shall adopt its own rules of procedure. It shall have the authority to impose penalties, other than dismissal and to recommend dismissal.

3. Institute Staff:
   Administrative Officers and Other Employees

   When a member of the Institute staff, other than a faculty member, has been charged with a violation of Institute rules, the charges shall be considered and determined administratively in accordance with established practices of the Institute. If the person against whom the charge has been made is both an administrative officer and a faculty member, the case shall be governed by this section unless the violative conduct was of such a nature as to call into question the person's continued qualification for service on the faculty. In the latter event, disciplinary action will proceed in accordance with Section II-B-2, above.

4. Student Organizations:

   If a student organization is charged with a violation of Institute rules, the charges shall be considered by the dean of student life and the penalty assessed will be in accordance with the penalties outlined below. The student organization can appeal the decision of the dean of student life to the Student Affairs Committee.

III. PENALTIES

Penalties for violation of Institute rules that may be imposed upon members of the Institute community include the following:

1. Reprimand
2. Censure
3. Removal of privileges
4. Suspension
5. Dismissal or expulsion
6. Rejection of permission for student organization to operate on campus
7. Other sanctions deemed appropriate

Students will not receive any tuition or fee refund for a semester in which they are suspended or expelled for disciplinary reasons.

ALCOHOL

Polytechnic Institute of New York does not condone the use of alcohol on campus. The Institute strictly adheres to the New York State law requiring individuals to be at least 19 years of age to drink.

All student groups wishing to hold events where beer or wine will be served must have permission of the dean of student life.

DRUG ABUSE

The State of New York has legal restrictions on the use of drugs which are enforced throughout the state. Because the Institute cannot protect those who break the laws of the state, it will not interfere with law enforcement agencies who may act upon information they obtain regarding illegal acts. The community may also desire, as in any other concern, through the disciplinary system, to be responsible in cases that involve campus abuse (both private and public) of drugs.

HAZING

The Institute complies with Section 6450 of the Education Law of the State of New York (as amended in 1980). Accordingly, any action or situation which recklessly or intentionally endangers mental or physical health or involves the forced consumption of liquor or drugs for the purpose of initiation into or affiliation with any organization is prohibited.
A BRIEF GUIDE TO COURSE DESCRIPTIONS

A variety of different symbols appear in the course listings for each of Polytechnic's departments and programs. The hypothetical example below contains all possible notations, and is followed by a complete explanation of its elements:

MA 563† Experimental Design* 2½:1½:4
Principles of modern statistical experimentation, including practice in the use of basic designs for scientific and industrial experiments and testing. Single factor experiments, randomized block design, Latin squares, Graeco-Latin squares, factorial and fractional factorial experiments, surface fitting designs. Prerequisite: MA 224. Co/Prerequisite: MA 153.
Also listed under IE 889

EXPLANATION

"MA 563" is the course number for which you must register. The dagger following the course number indicates that this course may be taken for either undergraduate or graduate credit.

"Experimental Design" is the course title. The asterisk following the title indicates that the course is not regularly offered each year. Such indicated courses may be offered either on a regular basis (every second or third year), or when there is sufficient student demand for the subject.

A course without an asterisk is normally offered at some time each year on one or more campuses. Check with the appropriate department to see which criterion applies to any particular course.

"2½:1½:4" means that the course meets for 2½ lecture hours and 1½ laboratory hours each week, and that a total of 4 credits (for undergraduate courses) or units (for graduate courses) are awarded upon successful completion of the course.

"Principles of modern... surface fitting designs" is the actual description of the curriculum to be covered in the course. Prerequisite: MA 224—means that a specific course (MA 224) must be successfully completed before registering for the course being described (in this case MA 563). Co/Prerequisite: MA 153 indicates that a specific course (MA 153) may be taken concurrently (during the same semester), or it must be successfully completed before registering for the course described, at the discretion of the adviser.

"Also listed under IE 889" means that the identical course is listed by another department, and therefore you may register under either course number. If one of the two departments offering the course is your major department, you should register under that department.
BIOENGINEERING

The dual-discipline program of bioengineering introduces the student to engineering in the health-related sciences. The curriculum includes engineering and life-science class work where both hardware and analytic applications are presented. Material coverage includes the instrumentation to acquire physiologic data and the techniques to analyze and process such data.

Bioengineers bring a new viewpoint to the life sciences. By use of their engineering training, they may conduct, direct or collaborate in research that provides a quantitative understanding of the living system. Their knowledge of the life sciences, when applied to related engineering problems, assures that the solution to the problems takes full account of the special properties of living systems. In short, bioengineers provide the intellectual link between engineering and the life sciences, a role that is increasingly important in biological and medical research and in industry.

DEGREE PROGRAMS

Polytechnic offers programs that lead to the master of science and doctor of philosophy degrees in bioengineering. While there is no undergraduate program at the present time, students may take a bioengineering concentration within most undergraduate engineering curricula.

REQUIREMENTS FOR THE MASTER'S DEGREE

It is expected that the undergraduate training of many students who enter the master's degree program will be deficient in certain areas. For this reason the program specifies a number of undergraduate requirements in chemistry, biology, mathematics and systems. These requirements (or their equivalent) must be completed before the student is permitted to register for graduate level courses in bioengineering. The required courses are offered as electives in the undergraduate school so that Polytechnic students who are interested in the program may complete them in their senior year. Students from other schools take these courses or show equivalent preparation.

The master's program consists of 36 units: 6 in mathematics, 18 in bioengineering, 6 in research and 6 in electives. The sequence permits students to maintain and expand their engineering background and to acquire experience with living systems simultaneously.

UNDERGRADUATE REQUIREMENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM122</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CM164</td>
<td>Physical Chemistry of Living Systems</td>
<td>3</td>
</tr>
<tr>
<td>LS105</td>
<td>General Biology I</td>
<td>4</td>
</tr>
<tr>
<td>BE201-202</td>
<td>Systems Approach to Biomedicine I, II</td>
<td>4</td>
</tr>
<tr>
<td>MA001</td>
<td>Review of Calculus</td>
<td>0</td>
</tr>
</tbody>
</table>

GRADUATE REQUIREMENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE600</td>
<td>Physiology Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BE602</td>
<td>Clinical Techniques</td>
<td>3</td>
</tr>
<tr>
<td>BE603</td>
<td>Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BE610-611</td>
<td>Physiology for Bioengineers</td>
<td>6</td>
</tr>
<tr>
<td>BE621</td>
<td>Instruments and Measurements in Physiological Systems</td>
<td>3</td>
</tr>
<tr>
<td>BE961-962</td>
<td>Colloquium in Bioengineering</td>
<td>0</td>
</tr>
<tr>
<td>Electives in Mathematics</td>
<td>(chosen with the approval of the adviser)</td>
<td>6</td>
</tr>
<tr>
<td>Electives in Bioengineering</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>BE996</td>
<td>Project</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
</tr>
</tbody>
</table>

Some laboratory sessions for the program are held at the nearby Long Island College Hospital, where live animal studies may be performed. The hospital has made many of its animal facilities available to the Polytechnic bioengineering program and has allocated space for live animal research. In addition, students associated with the program are exposed to the hospital environment and equipment used in clinical and diagnostic studies.

REQUIREMENTS FOR THE DOCTOR'S DEGREE

To be accepted into the bioengineering doctoral program, the student is required to pass a comprehensive qualifying examination. All students who have completed the course work toward the master's degree (excluding the project) with a B average or better are eligible to take the exam if they have been registered in
the program for at least the two semesters preceding the examination date.

After passing the qualifying examination, the candidate (in consultation with program advisers) plans a program of study which includes additional background for bioengineering (as noted below) and course work in two minor fields as chosen by the candidate. In addition, the student must exhibit an ability to read scientific literature in a foreign language and finally must present an acceptable doctoral dissertation on an elected research program. This research study for the doctor's degree is carried out under the direction of (and finally approved by) a guidance committee appointed by the vice president for research and graduate affairs.

Required Subject Areas

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Laboratory or Internship</td>
<td>5</td>
</tr>
<tr>
<td>Transportation Phenomena or Equivalents</td>
<td>6</td>
</tr>
<tr>
<td>Graduate Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>Bioengineering Electives or Equivalents</td>
<td>9</td>
</tr>
<tr>
<td>Research and dissertation (BE 999)</td>
<td>36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced Laboratory or Internship (as arranged with adviser)</td>
<td>5</td>
</tr>
<tr>
<td>Transportation Phenomena or Equivalents</td>
<td>6</td>
</tr>
<tr>
<td>Graduate Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>Bioengineering Electives or Equivalents</td>
<td>9</td>
</tr>
<tr>
<td>Research and dissertation (BE 999)</td>
<td>36</td>
</tr>
</tbody>
</table>

UNDERGRADUATE COURSES

**BE 201-202 Systems Approach to Biomedicine I, II**
- Introduction to modeling and simulation in biomedicine
- Characterization of resistive and storage properties of physiological systems and their analogs
- Analysis of systems with combined properties
- Transform rotation and transfer functions
- Impedance concepts with applications to pulmonary function and diffusion
- Periodic signals as related to physiological systems (breathing, EKG)
- Fourier expansion and frequency response
- Introductory concepts associated with feedback

Prerequisite: MA 102 or equivalent and permission of the student's departmental adviser. BE 202 prerequisites: BE 201.

GRADUATE COURSES

**BE 600 Physiology Laboratory**
- Studies of physiological specimens
- Microscopic studies of tissue, nerve and muscle
- Animal studies
- Co/Prerequisite: BE 610

**BE 602 Clinical Techniques Laboratory**
- Laboratory tests and measurements in biological specimens
- Determination of fluid properties—viscosity, refractive index, etc.
- Characteristics of pH meters, pH determinations, colorimetry, spectrophotometry, fluorometry, flame photometry
- Separation techniques—centrifuge, chromatography, electrophoresis
- Tracer techniques
- Co/Prerequisites: LS 105 and BE 610 and CM 164 or equivalent

**BE 603 Biophysics I**
- Physical properties of biological systems: Structural strength
- Elasticity of bones, muscle, other tissue
- Flow properties through tissue, diffusion of gases and liquids
- Flow through vessels
- Compartmental analysis, models, trace analysis
- Co/Prerequisites: LS 105 and CM 164 or equivalent
- Also listed under PH 635

**BE 604 Biophysics II**
- Transport processes and models of specific organs
- Application of radionuclides and dyes for imaging
- Neve conduction with a detailed discussion of the Hodgkin-Huxley and current models
- Prey-predator interactions on the cellular level in radiomunodissays and in population control
- Prerequisite: BE 603
- Also listed under PH 636

**BE 605 Radiation Physics with Biological and Medical Applications**
- Principles of atomic and molecular physics
- Problems of radiation protection and biological effects of ionizing radiation
- Radiation dosimetry and relationship between dose, biological behavior or radionuclides, reaction safety levels, effects of acoustical, microwaves, and thermal radiation
- Prerequisite: PH 335 or equivalent
- Also listed under PH 637

**BE 610-611 Physiology for Bioengineers I, II**
- Intensive course in human physiology
- Overall organization of the body: cells, tissue, organs, structure, fluids
- Properties and transportation of body fluids
- Renal function
- Cardio-pulmonary system
- Nervous system
- Gastrointestinal system
- Pre-requisites: CM 122 and LS 105 or equivalent
- BE 611 Prerequisites: BE 610

**BE 612 Advanced Physiology Laboratory**
- Live animal experiments and demonstrations to illustrate principles of physiology
- Principles of biological laboratory experimentation and techniques of animal experimentation
- Prerequisites: BE 600, BE 611 and BE 621

**BE 621 Instruments and Measurements in Physiological Systems**
- Theoretical and practical aspects of measurement problems in physiological systems
- Volume conductors: microelectrodes
- Techniques for acquiring body-generated signals
- Multi-phase screening systems
- EMG, EEG, EKG
- Readout devices and computer interface
- Digital instrumentation: telemetry
- Analog and digital computer simulation of biological systems
- Prerequisites: BE 201-202 and Co/Prerequisite: LS 105

**BE 623 Minicomputer Instrumentation for Scientific Research**
- Fundamentals of digital electronics and microcomputers
- Computer-automated laboratory instrumentation, programming and interfacing required for data acquisition and control in scientific research
- Experiments with minicomputers and laboratory apparatus interfaced directly to minicomputers
- Prerequisite: Instructor's permission
- Also listed under PH 612 and CM 760

**BE 650 Biomechanics**
- Fundamental basics of biomechanics interpreted in terms of human engineering and engineering mechanics
- Applications to industrial and medical problems
- Significant anatomical, kinesiological and physiological considerations
- Demonstration of applications to industrial as well as medical problems
- Also listed under ME 651

**BE 670 Biosystems**
- Examination of control functions in the body
- Types and properties of receptors
- Feedback mechanisms
- Performance tests, analysis and simulation of the cardiovascular, respiratory and fluid regulation systems
- Examination of pathological states based on simulated models
- Prerequisite: advisor's approval

**BE 675 Sensation and Perception**
- Overview of different sensory systems: vision, audition, taste, smell, touch, temperature, sensitivity, vestibular, kinesthetic senses
and their relation to nonsensory controlling stimuli. Techniques of obtaining psychophysical data on each sensory system, and the relation of these techniques to theories of discrimination. Available to undergraduate majors in social science with permission of instructor. Prerequisite: SS 189 or equivalent or instructor's permission.
Also listed under SS 912

BE 676 Comparative Psychology 2 1/2:0:3
Comparison of behavior of different species as function of their environments. Also available to undergraduate majors in social science with permission of instructor. Prerequisite: SS 189 or equivalent or instructor's permission.
Also listed under SS 912

BE 692 Neurophysiology* 2 1/2:0:3
An in-depth discussion of basic nerve cell physiology covering such topics as the resting potential, sodium pump, action potential, synaptic mechanisms and local neuronal circuits. Prerequisite: LS 106 or BE 611.
Also listed under LS 600

BE 693 Topics in the Neurosciences* 2 1/2:0:3
A review and discussion of various topics in the neurosciences. Typical topics will be neurotransmitters, motor control, developmental neurobiology, circadian rhythms, pain, neural modeling, neural correlates of central nervous system disorders, etc. Topics will vary from semester to semester and course may be taken for repeated credit. Prerequisite: LS 106 or BE 611 or instructor's permission.
Also listed under LS 601

BE 695 Physiological Psychology* 2 1/2:0:3
Review of physiological bases and correlates of behavior. Physiology of sensory systems, emotions, motivations and electrophysiological correlates of learning. Prerequisite: SS 189 or BE 111 or instructor's approval.
Also listed under SS 913

BE 741 Bioengineering Metallurgy I 2 1/2:0:3
Metals and alloys for use in the body environment. Examination of corrosion, excessive plastic deformation, fracture and stress-corrosion-cracking. Characterization of metals and alloys; atomic, microscopic and macroscopic structures. The phase diagram. Preparation of dental amalgams and other alloys. Also listed under MT 727

BE 742 Bioengineering Metallurgy II* 2 1/2:0:3

BE 800 Selected Topics in Bioengineering* 2 1/2:0:3
Topics of special current interest in bioengineering as announced in advance of a particular semester offering. Prerequisite: advisor's approval.

BE 935 Engineering Projects Related to Public Administration each 3 units
See Polytechnic's Cooperative Program with New York University's Graduate School of Public Administration on page 600 for details.

THESIS, COLLOQUIUM AND INTERNSHIP

BE 961-962 Colloquium in Bioengineering* no credit
Recent developments in the field of bioengineering through lectures given by engineers, scientists and physicians from industry, research, medical and educational institutions by staff members, and by qualified graduate students. Required for two semesters of all graduate students seeking degrees.

BE 971-972 Bioengineering Internship* each 3 units
Assignment of graduate students as members of selected hospital teams to observe hospital practice and participate where appropriate. Work directed by adviser from Polytechnic and leader of hospital team. Normally limited to students who have completed one full year of graduate study. Prerequisites: BE 602, BE 611, adviser's permission.

BE 996 Project each 3 units
Bioengineering project under guidance of qualified faculty member subject to approval of program adviser. Project may deal with any aspect of engineering applications in biological studies. Six units of project are required for the M.S. degree.

BE 999 Thesis for Degree of Doctor of Philosophy each 3 units
Thesis to give results of independent investigation of problem in bioengineering; requires thorough search of the literature and may involve experimental work or may be of a theoretical and analytical nature. Dissertation to show that original contribution has been made that is worthy of publication in recognized journals. Candidate required to take oral examination on subject of thesis and related topics. Total registration of 24 credits required. Prerequisites: degree status and successful performance on qualifying examination.

FACULTY

William B. Blesser, Professor and Director of Bioengineering
B.M.E., Rensselaer Polytechnic Institute; M.E.E., Polytechnic Institute of Brooklyn instrumentation, control systems, bioengineering

George Bugliarello, President and Professor
Dr. Ing., University of Padua (Italy); M.S., University of Minnesota; Sc. D., Massachusetts Institute of Technology bioengineering, social technology

Alfred L. Copley, Research Professor of Life Science and Bioengineering
M.D., University of Basel (Switzerland) biochemistry

Jesse F. Crump, Associate Professor of Bioengineering
B.S., M.D., University of Nebraska Physiology, bioengineering
ADJUNCT FACULTY

Gabor B. Levy, Adjunct Professor in Bioengineering
Ph.D., St. Thomas Institute of Cincinnati

Carl P. Mason, Adjunct Lecturer in Bioengineering
B.S.M.E., M.S. Bio.E., Polytechnic Institute of New York

PARTICIPATING FACULTY

Robert C. Ackerberg, Professor of Chemical Engineering

Patrick T. Cahill, Professor of Physics

Herbert Morawetz, Professor of Polymer Chemistry

Shirley M. Motzkin, Professor of Biology

Kurt Salzinger, Professor of Psychology

William R. Allen, Associate Professor of Mathematics

Saul W. Rosenthal, Associate Professor of Electrophysics

SUPPORTING AND ADVISORY STAFF

Doris Escher (Montefiore Hospital and Medical Center)
M.D., New York University
Pacemakers, cardiovascular studies

Henry Freedman (Long Island College Hospital)
M.D., New York University
Geriatrics

Paul Fried (Veterans Administration — Brooklyn)
M.S., Polytechnic Institute of Brooklyn
Biomedical engineering

Seymour Furman (Montefiore Hospital and Medical Center)
M.D., SUNY (Downstate Medical Center)
Pacemakers, cardiovascular studies

Parviz Lalezari (Montefiore Hospital and Medical Center)
M.D., University of Teheran (Iran)
Hematology

Harold A. Lyons (Downstate Medical Center and Kings County Hospital)
M.D., Long Island College of Medicine
Pulmonary function

Lenore R. Zohman (Montefiore Hospital and Medical Center)
M.D., SUNY (Downstate Medical Center)
Exercise cardiology
Students in the Chemical Engineering Department are taught to develop the knowledge and analytical skills which can be applied to bridge the technological gap between scientific advances and the economical production of new and useful products.

Chemical engineers rely heavily on science, the engineering method, experience and ingenuity to invent the processes and equipment required to make these products. Chemical engineers have contributed in an important way to the development of virtually every material common to modern life. They are involved with the production of petroleum products, plastics, pharmaceuticals, foods and synthetic rubber and rocket propellants, to name just a few. Their influence has been felt in the development of nuclear reactors, fuel cells, automatic controls, water desalting plants, missiles and artificial kidneys.

Individuals may choose to channel their energy into a very wide range of activities, including research, process and product development, design and supervision of the construction and operation of industrial plants, technical sales and services, consulting, management and teaching. It is a profession in which the opportunities for a stimulating, rewarding career are virtually unlimited.

The foundations of chemical engineering are the sciences with emphasis on chemistry, mathematics, physics and the engineering sciences including thermodynamics, fluid mechanics, kinetics and heat and mass transfer. Chemical engineering courses include the analysis, design and control of equipment, operations and processes.

**UNDERGRADUATE PROGRAM**

The undergraduate program in chemical engineering provides a sound foundation in science and the engineering sciences and builds on this a strong and integrated set of courses in chemical engineering. Thorough instruction is given in chemistry, physics, mathematics and in the engineering sciences basic to the understanding of physical and chemical operations and processes. Courses in engineering science include engineering thermodynamics, reaction kinetics, process dynamics, fluid mechanics, heat transfer and mass transfer.

The chemical engineering curriculum provides a background that enables the graduate to select a professional career from an extremely broad spectrum of opportunities. Graduates will be prepared to take employment in any one of a number of capacities in industry or to enter graduate school for advanced study in chemical engineering or other fields.

The Department of Chemical Engineering offers its undergraduate degree program at two campuses, Brooklyn and Long Island, with identical curricula and courses.

In addition to the regular program in chemical engineering, the department also gives students the opportunity to concentrate in one of three particular areas of wide current interest: biosystems, environmental studies and management. All are within the chemical engineering degree program.

The undergraduate program leads to the degree of bachelor of science in chemical engineering and is accredited by the Accreditation Board for Engineering and Technology.

In addition to the Institute's requirement of a 2.0 minimum average for graduation, students must meet the academic standards of the department. In order for a student to advance to the senior year, he/she must have maintained a 2.0 grade average in chemical engineering courses CH 123, CH 124, CH 220, CH 221, CH 241, CH 251 and must not have failed the same course twice. Students who do not meet this requirement will be advised to leave the program. All prerequisites must be satisfied before the student is permitted to enroll in chemical engineering courses.
Typical Course of Study for the Bachelor of Science Degree in Chemical Engineering

**REGULAR PROGRAM**

**Freshman Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
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<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr</td>
<td>No. Subject</td>
<td>Cl. Lab. Cr</td>
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<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 Intro. Physics I</td>
<td>3 0 3</td>
<td>PH 102 Intro. Physics II</td>
<td>3½ 1½ 4</td>
</tr>
<tr>
<td>CM 101 General Chemistry I</td>
<td>2½ 0 2½</td>
<td>CM 102 General Chemistry II</td>
<td>2½ 0 2½</td>
</tr>
<tr>
<td>CM 111 General Chemistry Lab I</td>
<td>0 1½ ½</td>
<td>CM 112 General Chemistry Lab II</td>
<td>0 1½ ½</td>
</tr>
<tr>
<td>HU 101 Composition a</td>
<td>3 0 3</td>
<td>CS 100 Intro to Computer Prog.</td>
<td>2 0 2</td>
</tr>
<tr>
<td>SS 104 Contemp. World Hist. a</td>
<td>3 0 3</td>
<td>HU 200 Lit West Civ. a</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE 101 Physical Education I</td>
<td>0 2 0</td>
<td>PE 102 Physical Education II</td>
<td>0 2 0</td>
</tr>
</tbody>
</table>

**Sophomore Year**

| MA 103 Calculus III | 3 0 3 | MA 104 Applied Diff. Eq. | 3 0 3 |
| PH 103 Physics III | 2½ 1½ 3 | AM 115 Engineering Mechanics | 4 0 4 |
| CM 122 Org. Chem. I | 3 0 3 | CM 123 Org. Chem. II | 3 0 3 |
| CM 124 Org. Chem. Lab I | ½ 5 2 | CM 161 Physical Chemistry I | 3 0 3 |
| PE 103 Physical Education III | 0 2 0 | CM 125 Physical Chemistry II | 3 0 3 |
| Total credits required for graduation: 136 |

**Junior Year**

| CH 220 Trans. Ops. I | 4 0 4 | CH 221 Trans. Ops. II | 4 0 4 |
| CH 251 Chem. Eng. Thermo. | 4 0 4 | CH 241 Multi. Sep. Proc. | 3 0 3 |
| CM 162 Physical Chemistry II | 3 0 3 | EE 370 Princ. Elect. Eng | 3 0 3 |
| Free elective a | 3 | EE 374 Instrument Lab. | 0 3 1 |
| Technical elective a | 3 | Free elective a | 3 |
| Total credits required for graduation: 136 |

**Senior Year**

| CH 301 Ch. E. Lab. I | 0 6 2 | CH 302 Ch. E. Lab. II | 0 6 2 |
| CH 322 Chem. Reac. Eng. | 3 0 3 | CH 271 Eng. Materials | 3 0 3 |
| CH 351 Proc. Dyn. & Control | 3 0 3 | CH 362 Proc. Design II | 3 0 3 |
| CH 381 Proc. Design | 3 0 3 | CM 116 General Biology I | 3 0 3 |
| HU 200 Lit West Civ. a | 3 0 3 | HU 202 Sys. App. to Biomed. II | 2 0 2 |
| Technical elective a | 3 | Free elective | 3 |
| Total credits required for graduation: 136 |

**BIOSYSTEMS CONCENTRATION**

Freshman and sophomore courses as in regular program

**Junior Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr</td>
<td>No. Subject</td>
<td>Cl. Lab. Cr</td>
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<td>4 0 4</td>
</tr>
<tr>
<td>CH 251 Chem. Eng. Thermo.</td>
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<td>CH 241 Multi. Sep. Proc.</td>
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<td>LS 106 General Biology I</td>
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<td>CM 116 General Biology Lab I</td>
<td>3 0 3</td>
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<tr>
<td>LS 115 General Biology Lab I</td>
<td>1 3 2</td>
<td>HU 202 Sys. App. to Biomed. II</td>
<td>2 0 2</td>
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<tr>
<td>BE 201 Sys. App. to Biomed. I</td>
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<td>Free elective</td>
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<tr>
<td>CM 162 Physical Chemistry II</td>
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<tr>
<td>Total credits required for graduation: 136</td>
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</tr>
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</table>

**Senior Year**

| CH 301 Ch. E. Lab I | 0 6 2 | CH 271 Eng. Materials | 3 0 3 |
| CH 322 Chem. Reac. Eng. | 3 0 3 | CH 302 Ch. E. Lab II | 0 6 2 |
| CH 351 Proc. Dyn. & Control | 3 0 3 | CH 362 Proc. Design II | 3 0 3 |
| CH 381 Proc. Design | 3 0 3 | BE 503 Biophysics a | 2½ 0 3 |
| BE 510 Physical & Bioengineering | 3 | HU 202 Sys. App. to Biomed. II | 2 0 2 |
| Technical elective a | 3 | Technical elective a | 3 |
| Total credits required for graduation: 136 |

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aSee item a under "Electives" on page 52.
bSee item b under "Electives" on page 53.
cSee item c under "Electives" on page 53.
dSee item d under "Electives" on page 53.
ENVIRONMENTAL STUDIES
CONCENTRATION
Freshman and sophomore courses as in regular program

Junior Year
First Semester
<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<td>CH 251</td>
<td>Chem Eng Thermo.</td>
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<tr>
<td>SS 182</td>
<td>Man and Env.</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<td>CM 162</td>
<td>Physical Chem. II</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<tr>
<td>LS 105</td>
<td>General Biology</td>
<td>3</td>
<td>0</td>
<td>3</td>
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Second Semester
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<tr>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tbody>
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<td>CH 221</td>
<td>Trans. Ops. II</td>
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<td>0</td>
<td>4</td>
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<tr>
<td>CH 241</td>
<td>Multi Sep. Proc.</td>
<td>3</td>
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<tr>
<td>LS 140</td>
<td>Env. Biol.</td>
<td>2½</td>
<td>½</td>
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<td></td>
<td>Hum./Soc. Sci. elective</td>
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<td></td>
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<tr>
<td></td>
<td>Technical elective</td>
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<td></td>
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<tr>
<td>CE 340</td>
<td>Water Res. Eng.</td>
<td>3</td>
<td>0</td>
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</table>

Senior Year
| CH 301 | Ch. E. Lab. I            | 6   | 0    | 2   |
| CH 322 | Chem React. Eng.         | 3   | 0    | 3   |
| CH 351 | Proc. Dyn. & Control     | 3   | 0    | 3   |
| CH 361 | Proc. Design I           | 3   | 0    | 3   |
| CE 341 | Env. Eng I               | 2   | 3    | 3   |
| CE 770 | Solid Waste Manag.       | 2½  | 0    | 3   |
|      |                          |     |      | 17  |

Total Credits required for graduation: 136

MANAGEMENT CONCENTRATION
Freshman and sophomore courses as in regular program

Junior Year
<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
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<tbody>
<tr>
<td>CH 220</td>
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<td>0</td>
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<tr>
<td>CH 251</td>
<td>Chem Eng Thermo.</td>
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<td>MG 300</td>
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<td>SS 251</td>
<td>Eco. II: Microeco.</td>
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<tr>
<td>CM 162</td>
<td>Physical Chem. II</td>
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<td>3</td>
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Second Semester
<table>
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<th>Subject</th>
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<th>Lab.</th>
<th>Cr.</th>
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<tr>
<td>CH 221</td>
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<td>0</td>
<td>4</td>
</tr>
<tr>
<td>CH 241</td>
<td>Multi Sep. Proc.</td>
<td>3</td>
<td>0</td>
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<tr>
<td>IE 252</td>
<td>Cost Fundamentals</td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SS 252</td>
<td>Eco. II: Microeco.</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<td>EE 370</td>
<td>Prin. Elect. Eng.</td>
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<td>EE 374</td>
<td>Instrument Lab.</td>
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<td>1</td>
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Senior Year
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<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tbody>
<tr>
<td>CH 301</td>
<td>Ch. E. Lab. I</td>
<td>6</td>
<td>0</td>
<td>2</td>
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<tr>
<td>CH 322</td>
<td>Chem React. Eng.</td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td>CH 351</td>
<td>Proc. Dyn. &amp; Control</td>
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<td>0</td>
<td>3</td>
</tr>
<tr>
<td>CH 361</td>
<td>Proc. Design I</td>
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<tr>
<td>IE 327</td>
<td>Ops. Research I</td>
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<td>Technical elective</td>
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<td>19</td>
</tr>
</tbody>
</table>

Total credits required for graduation: 136

See footnotes on previous page

ELECTIVES

Elective courses should be chosen in consultation with the chemical engineering undergraduate adviser subject to the following guidelines:

a. In the humanities and social sciences, the student must take HU 101 and either HU 200 and SS 104 or IS 140 and IS 141 (total 9 credits). Students who are placed in HU 103 on the basis of the English Composition Placement Test administered at Polytechnic to all incoming students may substitute HU 101 for HU 103. Each student must also elect at least 15 credits in the field of humanities and social sciences in addition to the above 9 credits.

The student is strongly urged to select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religion in the Department of Humanities, or political science, economics, history, anthropology, or psychology in the Department of Social Sciences) and to elect two or three courses in this concentration, in consultation with the adviser. A modern language may be chosen as a suitable concentration, but a student without prior knowledge of the language must plan to devote at least 12 credit hours to the subject.
For the remaining credits in the humanities/social sciences requirements, the student should select courses in areas other than that of the concentration. Additional courses in the humanities and social sciences may be taken as free electives.

Students in the management concentration option may count SS 251 and SS 252 (6 credits) as part of their humanities and social sciences requirements.

b. A total of 17 credits of technical electives (minimum) is necessary. In fulfilling this requirement the student should choose at least 3 credit hours of mathematics, plus 3 credit hours of chemical engineering elective courses and an additional 6 credit hours of physics, chemistry or life sciences. The remaining technical electives (5 credits) may be taken in any technical area in consultation with the departmental adviser. Students electing the biosystems, environmental studies or management concentration options may choose their electives in any technical area in consultation with their adviser.

c. Junior transfer students should take CH 123 and CH 124 in junior year in place of electives.

d. To be taken only with permission of undergraduate adviser. A 3.0 average is recommended.

**ROTC Adjustments—ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101-104 (physical education); juniors and seniors may substitute three of the following two-credit courses: MS 301, 303, 401 or 403 for six credits of technical electives.

## GRADUATE PROGRAM

The graduate programs in chemical engineering are designed to introduce students to advanced design, research and development. The Department of Chemical Engineering offers graduate programs leading to the degrees of master of science, engineer and doctor of philosophy in chemical engineering.

In addition, the Departments of Chemical Engineering and Chemistry jointly offer programs leading to the degrees of master of science and doctor of philosophy in polymer science and engineering. (See page 248.)

A degree in chemical engineering is generally required for admission to graduate study. The student must have had differential equations. Applicants with degrees in other fields or from other colleges may be admitted with undergraduate and/or graduate deficiencies as evaluated by the graduate adviser. The program leading to the master's in chemical engineering may be used either as a terminal course for development and advanced design, or as a research degree giving preliminary graduate training for the doctorate in chemical engineering.

A Stauffer Chemical Company Professional Internship is awarded annually to a master's candidate. In addition to providing tuition and a stipend to the student, a distinctive feature of the program is the summer internship whereby the student works for the Stauffer Chemical Company during the summer prior to graduate study.

The degree of engineer in the chemical engineering program is oriented toward those chemical engineers who wish to achieve a level of education in advanced process design beyond that normally possible for the master's degree.

The doctor of philosophy in the chemical engineering degree program provides advanced graduate study and research for the qualified student interested in research and development.

## REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN CHEMICAL ENGINEERING

Candidates for the degree of master of science in chemical engineering are to plan their programs in accordance with the following required courses.

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH631-632</td>
<td>Transport Phenomena I, II</td>
<td>6</td>
</tr>
<tr>
<td>CH771-772</td>
<td>Thermodynamics I, II</td>
<td>6</td>
</tr>
<tr>
<td>CH781</td>
<td>Chemical Process Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>CH821</td>
<td>Process Dynamics and Control</td>
<td>3</td>
</tr>
<tr>
<td>CH991-992</td>
<td>Seminar in Chemical Engineering</td>
<td>0</td>
</tr>
</tbody>
</table>

**Project/Thesis Option**

<table>
<thead>
<tr>
<th>Number</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 902</td>
<td>Guided Studies in Chemical Engineering</td>
<td>6</td>
</tr>
<tr>
<td>Electives (including 9 units chosen from CH 600 to CH 910)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>CH 997</td>
<td>Master's Thesis</td>
<td>9</td>
</tr>
<tr>
<td>Electives (including 6 units chosen from CH 600 to CH 910)</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>36</td>
</tr>
</tbody>
</table>

All electives are to be chosen in consultation with the graduate adviser.

To meet graduation requirements, a student may not obtain a grade of C (or lower) in more than three of the required subjects listed above, including required courses retaken for purposes of improving a grade. This requirement is in addition to the Institute's requirements for the master's degree.

## REQUIREMENTS FOR THE ENGINEER DEGREE IN CHEMICAL ENGINEERING

Applicants for admission to this program must hold a master's degree (or equivalent) comparable to that of the department. This must include at least the equivalent of the courses in transport phenomena, thermodynamics, chemical process kinetics, and process dynamics and control as a subset of the
overall prerequisite of the master's degree. Applicants lacking academic backgrounds in these courses will be obliged to satisfy these requirements as deficiencies prior to enrollment in the engineer's program.

Candidates for the degree of engineer in chemical engineering are to plan their programs in accordance with the following requirements of study are planned with the committee appointed by the office of graduate affairs for each candidate. The program is planned to give the student a thorough chemical engineering background accompanied by study in a minor field for the degree of engineer in chemical engineering are to plan their programs in accordance with the following required courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 851</td>
<td>Process Design and Synthesis</td>
<td>3</td>
</tr>
<tr>
<td>Chemical Engineering electives—chosen from CH 641, CH 721, CH 752, CH 766, CH 782, CH 815, CH 819, CH 852</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Electives (should include at least 3 units in applied mathematics)</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>CH 988</td>
<td>Chemical Engineering Design Project</td>
<td>9</td>
</tr>
<tr>
<td>CH 991-992 Seminar</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

All electives are to be chosen in conference with the graduate adviser.

On completion of the design project, the candidate is obliged to submit to an oral examination before a faculty committee. While the examination will focus on the subject of the project, its scope will not be limited thereto; the candidate could expect to be examined on his/her design competence in a broader sense.

**REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN CHEMICAL ENGINEERING**

Programs of study are planned individually with the candidate by members of the Department of Chemical Engineering. Systematic study toward a doctor's degree is carried out under the direction of a guidance committee appointed by the office of graduate affairs for each candidate. The program is planned to give the student a thorough chemical engineering background accompanied by study in a minor field chosen by the candidate. The student must pass a comprehensive qualifying examination in chemical engineering, exhibit a reading knowledge in a foreign language and present a doctoral dissertation.

Each candidate for the doctorate must complete a minimum of 90 units of academic work past the bachelor's degree, including a minimum of 30 units of dissertation research. Although the student may elect to take more than 30 units of Ph.D. thesis, only 30 units of Ph.D. thesis can be counted in the required 90 units past the bachelor's degree, and these must be taken at Polytechnic. Once the student has started the dissertation, registration must be continuous, excluding the summer session, until it is completed and accepted. Of the 90 units, a minimum of 30 units must be taken at Polytechnic. A minimum of 45 graduate units beyond the bachelor's degree (not including Ph.D. thesis) in chemical engineering subjects will be required, of which at least 18 units must be taken at Polytechnic. A minor is required at the chemical engineering seminars for at least four semesters. Each student must maintain an overall B average in those courses submitted for the doctoral degree.

For a degree in chemical engineering, the following courses are required and may be used to complete the 48 graduate units required in chemical engineering subjects:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 631-632</td>
<td>Transport Phenomena I, II</td>
<td>6</td>
</tr>
<tr>
<td>CH 771-772</td>
<td>Chemical Engineering Thermodynamics I, II</td>
<td>6</td>
</tr>
<tr>
<td>CH 781</td>
<td>Chemical Process Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>CH 782</td>
<td>Chemical Reactor Design, Simulation and Control</td>
<td>3</td>
</tr>
<tr>
<td>CH 821</td>
<td>Process Dynamics and Control</td>
<td>3</td>
</tr>
</tbody>
</table>

Students interested in the Ph.D. program should obtain a brochure outlining procedures and requirements, which is available from the office of the department head.

**UNDERGRADUATE COURSES**

**CH 123 Chemical Process Analysis I**


**CH 124 Chemical Process Analysis II**

Continuation of study of material and energy balances. Elementary thermodynamics and energy balances. Heats of reaction, solvation and mixing. Combined energy and material balances. Computer methods. Prerequisite: CH 123.

**CH 220 Transfer Operations I**

Introduction to transport processes from the standpoint of the laws of conservation: rate phenomena and natural and imposed constraints. Unit operations; distributed versus lumped-parameter systems. Momentum transport and fluid flow operations in laminar and turbulent flow. Prerequisites: CH 124 and MA 104 or adviser's approval.

**CH 221 Transfer Operations II**

Continuation of theory of transport operations with applications to chemical engineering systems. Energy and mass transport, heat transfer and diffusional mass transfer operations. Prerequisite: CH 220.

**CH 241 Multistage Separation Processes**

Unified treatment of separation processes utilizing the multistage model and mass and energy balances, e.g., absorption, extraction, distillation. The equilibrium stage, stage efficiencies, reflux and system parameters. Graphical, analytical and digital computer techniques of modeling stressed. Prerequisites: CH 220 and CH 251, or adviser's approval.

**CH 251 Chemical Engineering Thermodynamics**

First and second laws of thermodynamics, open and closed systems, thermodynamic properties of materials, generalized correlations for real fluids and multicomponent systems.
Chemical potential and its use in phase and chemical reaction equilibria. Prerequisites: CM 161 and CH 124, or adviser's approval.

CH 271 Engineering Materials 3:0:3
Structure, properties and uses of polymers and metals as engineering materials. Crystal structure, defects, heat treatment, corrosion and its prevention. Manufacture and processing of polymers. Mechanical behavior of polymers and their thermal and electrical properties. Prerequisites: CM 162 or CM 322, CM 123 and CM 124.
Also listed under MT 420

CH 301-302 Chemical Engineering Laboratory I, II each 0:6:2
Experimental study of operations in chemical engineering. Laboratory projects on the unit operations, transport processes, thermodynamics, reaction kinetics, process instrumentation, process dynamics and control. Design and conduct of experiments, interpretation of results, preparation of engineering reports. Data analysis done with aid of computer. CH 301 prerequisites: CH 241 and CH 221. CH 302 prerequisites: CH 301, CH 322 and CH 351.

CH 322 Chemical Reactor Engineering 3:0:3
Application of thermodynamics and chemical kinetics to analysis and design of chemical reactors and reactor systems. Homogeneous and heterogeneous reactors of various types. Uncatalyzed and catalyzed. Design of single and cascaded industrial reactors. Prerequisites: CH 221, CH 251 or instructor's permission.

CH 351 Process Dynamics and Control 3:0:3
Simulation, dynamics, instrumentation and control of chemical processes. Unsteady state behavior of processes and modeling, control theory. Process systems analysis via transient and frequency response methods; control systems design. Analog computer simulation. Prerequisites: CH 221, CH 241, MA 104, or adviser's approval.

CH 361 Process Design I 3:0:3

CH 362 Process Design II 3:0:3
Design of large chemical process systems, with special emphasis on more complex, integrated process schemes and systems optimization. Prerequisites: CH 322 and CH 361.

CH 380-381 Chemical Engineering Project each 2 credits
Independent work in an area of interest in chemical engineering selected by the student and faculty supervisor. Not open to honors or senior thesis students. CH 380 only or both CH 380 and CH 381 may be taken. Prerequisite: department's approval.

CH 391-394 Bachelor's Thesis in Chemical Engineering each 2 credits
Original investigation of a problem in chemical engineering. A thorough search of the literature required. Special apparatus constructed as required for experimental work.

CH 396 Chemical Engineering Internship 2 credits
A supervised, creative engineering experience of at least two months' duration, typically taken during the summer, culminating in a written and oral report presented to the industrial and faculty supervisor. Faculty evaluations and committees during the internship arranged. Prerequisite: senior standing and adviser's approval.

CH 399 Senior Honors Work in Chemical Engineering credit to be arranged
Independent work undertaken by qualified honors students under faculty guidance.

GRADUATE COURSES

CH 611+ Unit Processes of Chemical Technology 2:3:0:3
Study of the more important chemical industries, their processes and products. Effects of process variables on end products and needs for variation in properties of products as determined by market demands. Interlocking chemical industries. Product planning and marketing. Prerequisite: instructor's permission.

CH 612† Chemical Process and Project Evaluation 2:3:0:3
Analysis of the design and operation of chemical process plants and their individual components, with attention directed to the integrated and consistent use of technical and economic information. Special consideration given to optimizing the design of chemical plant pumping, process piping, heat transfer, recovery systems, etc., as well as various mass transfer operations such as distillation, gas absorption, stripping and liquid extraction. Prerequisite: CH 361 or equivalent.

CH 631-632 Transport Phenomena I, II each 2:3:0:3
Fundamental concepts of momentum, energy and mass transport. Transport in stationary and flowing systems, steady-state and transient conditions. Elementary Cartesian vector and tensor analysis; conservation equations for general cases and in macroscopic form; rate expressions. Fluid dynamics, energy transfer and diffusion, turbulent transport, transport coefficients, analogies, dimensional analysis, boundary layers, high rates of mass transport. Applications to chemical engineering systems stressed. CH 631 prerequisites: CH 220 and CH 221, or equivalent; CH 632 prerequisite: CH 631.

CH 641 Particle Transport Processes* 2:3:0:3

CH 712 Mass Transfer Operations* 2:3:0:3
Unified treatment of mass transfer operations such as distillation, absorption and extraction. Phase equilibria and thermodynamic correlations for binary, multicomponent and complex systems. Engineering design methods of stagewise and differential contact operations, including machine computational techniques. Developments in these areas. Prerequisite: instructor's permission.

CH 742 Design of Solid Waste Processing Systems* 2:3:0:3
An evaluation of advanced solid waste processing technology with particular emphasis on processes still under development. Incineration and pyrolysis design for heating value recovery and effluent recovery. Separation for recovery of valuable raw materials. Other modem techniques. Prerequisite: adviser's permission.

CH 752 Air Pollution Engineering Control* 2:3:0:3
Pollutant emissions control. Analysis of pollutant properties, concentrations and boundary conditions; adsorption, and reactive recovery processes for moving and stationary sources: formation and removal of gaseous oxides (NO, SO2, CO, etc.) and of aerosols and other particulates. Prerequisite:
56

CH 753 Dispersion of Pollutants 2%:0:3
Also listed under CE 758

CH 755 Air Pollution Chemistry* 2%:0:3
Significant chemical reactions occurring in lower atmosphere and basic chemistry required to understand problems peculiar to air pollution field. Also, chemistry applicable to fuels combustion and other sources of atmospheric pollution.
Also listed under CE 755

CH 756 Air Pollution Analysis* 2%:0:3
Principles of reaction or physical measurement used for various analytical equipment employed in air pollution studies. Analysis of various atmospheres and evaluation of results.
Also listed under CE 756

CH 757 Air Pollution Effects 2%:0:3
Effects of atmospheric pollution on various forms of life, including both direct and secondary effects. Corrosion of contamination of inert matter by pollutants in the atmosphere. Legal aspects and community organization for control of atmospheric pollutants.
Also listed under CE 757

CH 760 Energy Resources, Conversion Technology, Distribution Utilization* 2%:0:3
Comprehensive study of the energy problem in terms of available and potential resources of primary energy, conversion technology, distribution and utilization, with emphasis on both economic and technical factors. Present and possible future environmental impact. Prerequisite: instructor's permission.

CH 765 Process Heat Transfer* 2%:0:3
Thermal design of industrial heat exchangers, including condensers and forced and natural circulation reboilers; process design of fired heaters; optimum use of extended surfaces; heat transfer and power requirements of agitated jacketed vessels. Prerequisite: instructor's permission.

CH 771 Chemical Engineering Thermodynamics I 2%:0:3
Laws of thermodynamics, conditions for thermodynamic equilibria; use of equations of state and the principle of corresponding states to determine changes in thermodynamic properties for pure substances and mixtures. Chemical potential, standard states, ideal solutions, introduction to chemical and phase equilibria. Prerequisite: CH 251 or equivalent.

CH 772 Chemical Engineering Thermodynamics II 2%:0:3
Advanced treatment of chemical and phase equilibria phase rule, Gibbs-Duhem equation, non-ideal solutions; stability of thermodynamic systems, osmotic pressure, surface tension, thermodynamic equilibria in potential fields; introduction to irreversible thermodynamics. Prerequisite: CH 771 or equivalent.

CH 781 Chemical Process Kinetics 2%:0:3
Reactor analysis, and design; segregation and maximum- mixedness; selectivity in laminar and dispersed flows, variable density flows; numerical and statistical analysis of nonlinear systems; multistage reactors, chemisorption and pore diffusion, steady-state multiplicity; packed bed momentum trans-

CH 782 Chemical Reactor Design, Simulation Control* 2%:0:3
Design of industrial reactors, optimization of reactors, dynamic behavior of reactors, modeling of reaction rates, computer simulation of reactors, stability and control of reactors. Case studies. Prerequisite: CH 791 or equivalent

CH 784 Catalysis* 2%:0:3
Catalytic processes and engineering problems associated with each process. Review of catalytic chemistry, relationships between chemistry and choice of processing conditions with choice of catalyst composition and structure. Experimental methods in catalytic research; relation of processing conditions to chemistry and transport effect. Prerequisite: CH 781 or equivalent.

CH 791 Electrochemical Engineering* 2%:0:3
Theory and measurement of reversible and irreversible electrochemical processes at metal-electrolyte interfaces. Thermodynamics, kinetics, mass transport, mixed potential theory, passivation. Modern experimental techniques. Electrochemical energy conversion devices (batteries and fuel cells). Prerequisite: CM 162 or equivalent.

CH 815 Applied Mathematics in Chemical Engineering 2%:0:3
Mathematical formulation of chemical engineering problems in terms of ordinary, partial differential and difference equations. Solutions of boundary and initial value problems using Green's functions and other techniques. Characterization of second-order partial differential equations and properties of their solutions. Asymptotic methods, numerical techniques. Prerequisite: MA 260 or MA 531 or instructor's permission.

CH 818 Machine Computation in Chemical Engineering 2%:0:3
Digital computer applications in chemical engineering. Topics include programming languages such as FORTRAN, analog simulation languages such as CSMP, and general simulation techniques using GPSS. Applications to material and energy balances, design and optimization of distillation processes, heat transfer apparatus, process flow sheets, use of matrix methods in formulating and solving chemical engineering problems. Prerequisite: CS 100 or equivalent.

CH 821 Process Dynamics and Control 2%:0:3
Instrumentation and control of chemical processes from viewpoint of system engineering. Unsteady state behavior of chemical engineering systems. Analysis of closed-loop feedback systems for control of variables of chemical processes equipment. Prerequisite: CH 351 or equivalent.

CH 841 Research Instrumentation* 2%:0:3
Laboratory course in electronics for students who find it necessary to use electronic instrumentation in research programs. Mainstay/Coke instrumentation, laboratory used. Topics include power supplies, vacuum-tube and solid-state amplifiers, oscillators, servo-systems, operational amplifiers and digital instrumentation. Prerequisite: advisor's approval.

CH 851-852 Process Design and Synthesis I, II* each 2%:0:3
Design of complex chemical process plants. Use of optimization techniques in design. Selection of design techniques and process alternatives. Evaluation and design of projects in the light of uncertainty. Factors affecting design and erection of plants such as market, plant location, raw material availability. CH 851 prerequisite: CH 781 or equivalent; CH 852 prerequisite: CH 851.
CH 862 Rheology of Non-Newtonian Fluids  2 1/2:0:3

CH 872 Fundamentals of Biochemical Engineering  2 1/2:0:3

CH 900-901 Selected Topics in Chemical Engineering* each 2 1/2:0:3
Topics of special current interest in chemical engineering, as announced in advance of a particular semester offering. Prerequisite: advisor's approval.

CH 927 Energy Policy Issues  2 1/2:0:3
See Energy Program for details.

CH 928 Energy Resource Distribution and Conversion Technology  2 1/2:0:3
See Energy Program for details.

CH 935 Engineering Projects Related to Public Administration each 3 units
See Polytechnic's Cooperative Program with New York University's Graduate School of Public Administration for details.

POLYMER SCIENCE AND ENGINEERING

CH 917 Introduction to Polymeric Materials  2 1/2:0:3
Principles of technological aspects of polymerization, compounding and processing of polymeric materials, their properties and applications. Thermoplastic materials such as polyethylene, polypropylene, polystyrene, acrylics and engineering plastics will be discussed. Thermoforming materials to be covered include: phenolics, epoxies, unsaturated polyesters, aminoplastics, polyurethanes and silicones. Prerequisite: CM 123 or equivalent.

CH 921 Polymer Processing  2 1/2:0:3
Applications of engineering principles of polymer processing. Study of non-Newtonian polymeric systems. Extrusion theory and applications. Discussions and problem-solving in compression, transfer and injection molding, thermofoming, and polymerization, as well as other polymer engineering processes. Prerequisites: CH 220 and CH 221 or instructor's permission.

CH 922 Polymer Processing Laboratory  0:4:3
Laboratory study of engineering principles and processes involved in polymer processing and analysis. Experiments include injection molding, extrusion, thermoforming, mixing and compounding, melt rheology, flat-and-blown film extrusion, blow molding, etc. Prerequisite: CH 921.

CH 923 Industrial Polymerization Processes*  2 1/2:0:3
Analytical study of principal processes used to synthesize polymers, including polymer engineering operations, equipment, polymerization control, instrumentation, process economics. Emphasis on development and solution of polymer plant engineering problems. Prerequisite: CM 771.

CH 926 Engineering Properties of Polymers  2 1/2:0:3

CH 933 Coatings Technology  2 1/2:0:3

CH 940-941 Selected Topics in Polymer Science and Engineering I, II  each 2 1/2:0:3
Topics of special interest in polymeric materials as announced in advance of particular semester offering. Prerequisite: advisor's approval.

PROJECT, THESIS AND SEMINAR

CH 902 Guided Studies in Chemical Engineering  6 units, each 2 units
Selection, analysis, solution and presentation of an engineering report of some problem in process or equipment design, thermodynamic study or correlation, or another field of chemical engineering practice under supervision of staff member. Conferences scheduled. Candidates for master's degree required to submit three unbound copies of typewritten report to adviser one week before the last day of classes. Prerequisite: degree status.

CH 930 Guided Studies in Polymer Science and Engineering  6 units, each 2 units
Selection, analysis, solution and presentation of a comprehensive report of some problem involving polymeric materials, such as polymer synthesis, processing, evaluation, equipment design, etc. Conducted under supervision of staff member. Conferences scheduled. Candidates for master's degree required to submit three unbound copies of typewritten project report to adviser one week before last day of classes. Prerequisite: degree status.

CH 997 Thesis for Degree of Master of Science in Polymer Science and Engineering  6 units, each 2 units
Thesis for master's degree in polymer science and engineering should give results of original investigation of problem in the chemistry and chemical engineering of polymeric materials. Thesis may involve experimental research, theoretical analysis, or process design, and possibly a combination thereof. Candidates for master's degree required to submit four typewritten unbound thesis copies to advisers before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

CH 998 Dissertation for Degree of Doctor of Philosophy in Polymer Science and Engineering  30 units, each 3 units
See description for CH 999. A wide variety of problems may be selected from topics in polymer science and engineering. Prerequisite: see CH 999.

CH 999-992 Seminar in Chemical Engineering  0 units
Recent developments in the field of chemical engineering presented through lectures given by engineers from industry, re-
search and educational institutions, by staff members and by qualified graduate students. Required for two semesters of all graduate students seeking degrees.

**CH 997 Thesis for Degree of Master of Science in Chemical Engineering** 9 units, each 3 units

Thesis for master's degree in chemical engineering should give results of original investigation of a problem in chemical engineering or application of physical, chemical or other scientific principles to chemical engineering. Thesis may involve experimental research, theoretical analysis or process design, and possibly a combination thereof. Candidates for master's degree required to submit four typewritten unbound thesis copies to advisors before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

**CH 998 Chemical Engineering Design Project** 9 units, each 3 units

Engineering analysis, synthesis, optimization and design of a process or novel equipment. Project requires original individual work. Evaluation of results, use of engineering judgment and excellence in reporting emphasized. Conducted under supervision of staff member. Conferences scheduled. Candidates for engineer degree required to submit four unbound copies of typed written project report to advisors before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

**CH 999 Dissertation for Degree of Doctor of Philosophy in Chemical Engineering** 30 units, each 3 units

Dissertation must give results of independent investigation of a problem in chemical engineering and may involve experimental and/or theoretical work. Thesis must show ability to do creative work and that an original contribution has been made to chemical engineering, which is worthy of publication in recognized journals. Candidate required to take an oral examination on subject of thesis and on related topics. Candidates for doctor's degree required to submit five unbound thesis copies to advisors before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

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**FACULTY**

**Robert F. Benenati,** Professor and Head of Chemical Engineering
B.Ch.E., M.Ch.E., Ph.D., Polytechnic Institute of Brooklyn

*Computer applications to process design, packed and fluidized beds, heat transfer*

**Robert C. Ackerberg,** Professor of Chemical Engineering
B.S., Massachusetts Institute of Technology; M.S.E., University of Michigan, M.A., Ph.D., Harvard University

*Fluid mechanics, applied mathematics, thermodynamics*

**James J. Conti,** Professor of Chemical Engineering and Vice President for Educational Development
B.Ch.E., M.Ch.E., D.Ch.E., Polytechnic Institute of Brooklyn

*Transport processes, biomedical engineering*

**Chang Dae Han,** Professor of Chemical Engineering and Director of Polymer Science and Engineering Program
B.S., Seoul National University; M.S., Sc.D., Massachusetts Institute of Technology; M.S., Newark College of Engineering; M.S., New York University

*Rheology, polymer processing, process control*

**William H. Kapfer,** Professor of Chemical Engineering
B.Ch.E., M.Ch.E., Eng.Sc.D., New York University

*Polymeric materials, plant design economics*

**Eli M. Pearce,** Professor of Polymer Chemistry and Chemical Engineering and Dean of Arts and Sciences
B.S., Brooklyn College; M.S., New York University; Ph.D., Polytechnic Institute of Brooklyn

*Polymer synthesis and degradation*

**Jovan Mijovic,** Associate Professor of Chemical Engineering
B.S., University of Belgrade; M.S., Ph.D., University of Wisconsin (Madison)

*Polymer morphology, fracture properties of polymers, adhesives and composites*

**Leonard I. Stiel,** Associate Professor of Chemical Engineering
B.S., Massachusetts Institute of Technology; M.S., Ph.D., Northwestern University

*Thermodynamic properties of mixtures, properties of polar fluids*

**Edward N. Ziegler,** Associate Professor of Chemical Engineering
B.Ch.E., CCNY; M.S., Ph.D., Northwestern University

*Kinetics and reactor design, air pollution control, fluidization*

**Elliot Sadic,** Visiting Assistant Professor of Chemical Engineering
B.S., New Jersey Institute of Technology

*Kinetics and thermodynamics of heterogeneous systems*

**Paul F. Schubert,** Assistant Professor of Chemical Engineering
B.S., University of Notre Dame; Ph.D., Cornell University

*Transport processes, separation sciences, biochemical engineering*

---

**ADJUNCT FACULTY**

**C. Fred Chueh,** Adjunct Professor of Chemical Engineering
B.S., National Taiwan University; M.S., Kansas State University; Ph.D., Georgia Institute of Technology

**Herbert W. Cooper,** Adjunct Professor of Chemical Engineering
B.Ch.E., M.Ch.E., CCNY; Eng.Sc.D., Columbia University

**Gunther Geiss,** Adjunct Professor of Chemical Engineering
B.E.E., M.E.E., Ph.D., Polytechnic Institute of New York
W. Lincoln Hawkins, Adjunct Professor of Chemical Engineering
Chemical Engineering, Rensselaer Polytechnic Institute; N.S., Howard University; Ph.D., McGill University

Olagoke Olabisi, Adjunct Professor of Chemical Engineering
B.S., Purdue University; M.S., New Jersey Institute of Technology; M.S., University of California, Berkeley; Ph.D., Case Western Reserve University

Joseph W. Prane, Adjunct Professor of Chemical Engineering
B.Ch.E., CCNY; M.S., Columbia University

Irven H. Rinard, Adjunct Professor of Chemical Engineering
B.Ch.E., University of Delaware; S.M., Sc.D. (Ch.E.), Massachusetts Institute of Technology

Alexander Walzer, Adjunct Professor of Chemical Engineering
B.Ch.E., CCNY; M.Ch.E., New York University

Chee-Gen Wan, Adjunct Professor of Chemical Engineering
B.S., National Taiwan University; M.S., Kansas State University; Ph.D., Polytechnic Institute of New York

Israel Wilenitz, Adjunct Professor of Chemical Engineering
B.S., University of London; M.S., Ph.D., Polytechnic Institute of New York

EMERITUS FACULTY

Paul F. Bruins, Professor Emeritus of Chemical Engineering
B.S., Central College, Iowa; M.S., Ph.D., Iowa State University; D.Sc. (Hon.), Polytechnic Institute of New York
Plastics technology, electrochemistry, materials science

Donald F. Othmer, Professor Emeritus of Chemical Engineering
B.Ch.E., D.Sc., University of Nebraska; M.Ch.E., Ph.D., University of Michigan; D. Eng. (Hon.), New Jersey Institute of Technology
Energy conversion process, thermodynamics of phase equilibria

W. Fred Schurig, Professor Emeritus of Chemical Engineering
B.Ch.E., M.Ch.E., D.Ch.E., Polytechnic Institute of Brooklyn
CHEMICAL PHYSICS

GRADUATE DEGREE PROGRAMS

The chemical physics program at Polytechnic is designed to train students for careers in areas common to chemistry and physics. It provides, within the scope of a normal graduate program, an unusual overlap of studies in both departments, emphasizing aspects that are closely related to both fields. Typical areas of interest include aspects of quantum and theoretical chemistry, statistical mechanics, solid-state physics and chemistry, molecular structure, x-ray crystallography, nuclear and electron resonance, the structure of liquids, the study of surfaces and biophysics.

Students normally enter the program with undergraduate degrees in chemistry, physics or mathematics. All applicants should take the Graduate Record Examination. Students spend the first year in the program developing competence in those areas of chemistry, physics and mathematics that are outside their undergraduate training. Guided by the graduate adviser, students select a plan of study suited to their individual needs and interests; thus there are no formal specific course requirements for a master's or doctor's degree. Representative first-year programs for students entering graduate study in chemical physics are:

### Representative Program for First-Year Students

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 703</td>
<td>Chemical Physics I</td>
<td>4½</td>
</tr>
<tr>
<td>CM 704</td>
<td>Chemical Physics II</td>
<td>4½</td>
</tr>
<tr>
<td>MA 630</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>MA 839</td>
<td>Introduction to Functional Analysis</td>
<td>3</td>
</tr>
<tr>
<td>CM/PH 995-996</td>
<td>Seminar in Chemical Physics</td>
<td>3</td>
</tr>
<tr>
<td>CM 971-972</td>
<td>Chemistry Colloquium</td>
<td>0</td>
</tr>
<tr>
<td>PH 901-902</td>
<td>Physics Colloquium</td>
<td>0</td>
</tr>
</tbody>
</table>

Students with baccalaureate degrees in chemistry:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 260</td>
<td>Vector Analysis and Partial Diff. Eqs.</td>
<td>4</td>
</tr>
<tr>
<td>PH 313-314</td>
<td>Introduction to Theoretical Physics</td>
<td>6</td>
</tr>
</tbody>
</table>

Students with baccalaureate degrees in physics:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>CM 161-162</td>
<td>Physical Chemistry I, II</td>
<td>6</td>
</tr>
<tr>
<td>CM 601</td>
<td>Inorganic Chemistry</td>
<td>4½</td>
</tr>
</tbody>
</table>

Thesis, project and/or electives chosen from chemistry, physics, mathematics

### REQUIREMENTS FOR THE MASTER'S DEGREE

The program of study for the degree of master of science in chemical physics offers three options, each requiring 36 units. One option, including early formal research, consists of a 12-unit thesis and 24 units of required and elective courses. In another option, candidates with suitable experience may substitute a six-unit project and six additional electives for the 12-unit thesis. The project requires a literate and critical discussion of the current status of a specialized area of research and demonstration of the student's professional maturity. The project is completed by the submission of an acceptable written report and by its satisfactory defense in an examination.

The third option emphasizes a strong formal training in courses and is acceptable as well as advised only for students planning to proceed to the doctorate. The Ph.D. qualifying examination will generally serve as the M.S. final examination. Satisfactory passing is required.

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 971-972</td>
<td>Chemistry Colloquium</td>
<td>0</td>
</tr>
<tr>
<td>PH 901-902</td>
<td>Physics Colloquium</td>
<td>0</td>
</tr>
<tr>
<td>CM/PH 995-996</td>
<td>Seminar in Chemical Physics (to be taken with either colloquium)</td>
<td>3</td>
</tr>
</tbody>
</table>

Students with baccalaureate degrees in chemistry:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 260</td>
<td>Vector Analysis and Partial Diff. Eqs.</td>
<td>4</td>
</tr>
<tr>
<td>PH 313-314</td>
<td>Introduction to Theoretical Physics</td>
<td>6</td>
</tr>
</tbody>
</table>

Students with baccalaureate degrees in physics:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 161-162</td>
<td>Physical Chemistry I, II</td>
<td>6</td>
</tr>
<tr>
<td>CM 601</td>
<td>Inorganic Chemistry</td>
<td>4½</td>
</tr>
</tbody>
</table>

Thesis, project and/or electives chosen from chemistry, physics, mathematics

A reading knowledge of French, German, Japanese or Russian is required; students whose native language is not English will be required to demonstrate adequate mastery of English.

*To be chosen from approved courses in chemistry, mathematics and physics in consultation with adviser.
† Under special circumstances, CM 951-2, Experiment Design I, II, may be substituted for the project.
‡ Advised and allowed only for students intending to proceed to the doctorate.
REQUIREMENTS FOR THE DOCTOR'S DEGREE

The requirements for the doctorate conform to the general regulations given elsewhere in this catalog. Both the major and minor fields are generally chosen from the areas of chemical physics, chemistry, physics and mathematics. The student is expected to pass examinations which form part of those regularly given to graduate students in the Departments of Chemistry and Physics. The candidate must also demonstrate a reading knowledge of scientific French, German, Japanese or Russian. Students whose native language is not English will be required to demonstrate adequate competence in English.

The most important requirement is the preparation of a dissertation embodying a substantial research contribution in chemical physics.

Students may apply for admission to the chemical physics program either simultaneously with their application for admission to the graduate school or at a later time. Special application forms, as well as additional information, are available from the Office of the Dean of Arts and Sciences.

FACULTY INTERDEPARTMENTAL COMMITTEE

Bruce A. Garetz, Associate Professor of Chemistry; Chairman, Chemical Physics Committee

*Ronald D. Parks, Professor of Physics and Chemistry and Head of Physics

*Yoshiyuki Okamoto, Professor and Head of Chemistry

*Ell M. Pearce, Professor of Chemistry and Dean of Arts and Sciences

Ernest M. Loeb, Professor of Chemistry

PARTICIPATING FACULTY

Stephen Arnold, Professor of Physics

Ephraim Banks, Professor of Chemistry

Bernard J. Bulkin, Professor of Chemistry and Vice President for Research and Graduate Affairs

Patrick T. Cahill, Professor of Physics

Hellmut J. Juretschke, Professor of Physics

Norman C. Peterson, Professor of Chemistry

Arnold Reiser, Research Professor of Chemistry and Deputy Director of the Institute of Imaging Sciences

Marcus Vlase, Associate Professor of Chemistry

Marten denBoer, Assistant Professor of Physics

Donald M. Schleich, Assistant Professor of Chemistry

Andrew Zangwill, Assistant Professor of Physics

*ex officio
CHEMISTRY

Chemistry is concerned with our ever-expanding knowledge of the structure, properties and reactions of matter and our evolving theories to explain our observations, predict chemical behavior and suggest experiments.

The classical divisions of chemistry were organic chemistry, dealing primarily with compounds of carbon; inorganic chemistry, concerned with all other compounds; analytical chemistry, concerned with qualitative and quantitative determinations of composition; and physical chemistry, which seeks to provide an understanding of the properties of matter, including chemical bonds and molecular interactions. These classical fields have overlapped increasingly, however, and several inter-disciplinary fields of study are now of great importance. Examples are biochemistry, electrochemistry, photochemistry, polymer chemistry and chemical physics.

Polytechnic's Department of Chemistry offers a full complement of undergraduate and graduate courses in important aspects of modern chemistry. Graduates are prepared for meaningful positions with educational institutions, research institutes, industrial organizations and government laboratories.

The department is active in research, with staff members conducting and supervising research at both undergraduate and graduate levels. This research is combined with teaching so that courses at all levels are taught by chemists who are highly competent in their respective fields.

The participation of undergraduates in a variety of research activities provides them with both stimulus and exceptionally good preparation for graduate school or a professional position.

The department offers programs leading to the degrees of bachelor of science, master of science, and doctor of philosophy in chemistry, and the degree of master of science in industrial chemistry.

The department also offers joint programs with the Department of Physics and the Department of Chemical Engineering, as described in this section.

CHEMICAL PHYSICS PROGRAM

Chemical physics is an interdisciplinary program designed to train students for careers in those areas common to chemistry and physics. Administered jointly by the Departments of Chemistry and Physics, it provides, within the scope of a normal graduate program, a flexible course of study in both departments. The program leads to the degrees of master of science and doctor of philosophy. (For details, see special listing.)

POLYMER SCIENCE AND ENGINEERING

Polymer science and engineering is an interdisciplinary program, administered jointly by the Departments of Chemistry and Chemical Engineering, leading to the degrees of master of science and doctor of philosophy. (For details, see special listing.)

UNDERGRADUATE PROGRAM

For the student majoring in chemistry, the Department of Chemistry provides a curriculum that goes beyond the educational requirements of the American Chemical Society for professional training. The courses offered are professional courses designed to prepare the candidate for graduate study or for work in industry.

Bachelor of science degrees are certified by the ACS, and graduates are immediately eligible for membership in the American Chemical Society.

Requirements for the Degree of Bachelor of Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 101, 102, 108, 109, 111, 112, 118-120</td>
<td>45</td>
</tr>
<tr>
<td>122-125, 161, 162, 175, 177, 501, 504, 508</td>
<td>45</td>
</tr>
<tr>
<td>Advanced Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>Thesis Research (CM 390-394)</td>
<td>10</td>
</tr>
<tr>
<td>CS 100</td>
<td>2</td>
</tr>
<tr>
<td>MA 101-104</td>
<td>14</td>
</tr>
<tr>
<td>PH 101-103</td>
<td>10</td>
</tr>
</tbody>
</table>

The minimum of 128 credits required for the degree of bachelor of science in chemistry includes a minimum of 30 credits in humanities/social sciences.
Curriculum for Bachelor of Science in Chemistry

**Freshman Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
<td><strong>Cl. Lab. Cr.</strong></td>
<td><strong>No.</strong></td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry</td>
<td>2½ 0 2½</td>
<td>CM 102</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab.</td>
<td>0 1½ ½</td>
<td>CM 112</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>6 0 6</td>
<td>MA 102</td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics</td>
<td>3 0 3</td>
<td>PH 102</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>0 2 0</td>
<td>CS 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PE 102</td>
</tr>
</tbody>
</table>

**Sophomore Year**

| CM 122                  | Organic Chemistry I | 3 0 3 | CM 123                  | Organic Chemistry II | 3 0 3 |
| CM 124                  | Organic Chemistry Lab. I | ¾ 5 2 | CM 125                  | Organic Chemistry Lab. II | ¾ 5 2 |
| MA 103                  | Calculus III | 6 0 6 | MA 104                  | Applied Calc. | 3 0 3 |
| PH 103                  | Introductory Physics III | 3 0 3 | PE 104                  | Physical Education | 0 2 0 |

**Junior Year**

| CM 118                  | Chemical Equilibria | 2½ 5 4 | CM 108                  | Inorganic Chemistry | 3 0 3 |
| CM 162                  | Physical Chemistry II | 3 0 3 | CM 119                  | Analytical Chemistry | 3 0 3 |
| CM 501                  | Chemical Literature | 1 0 1 | CM 120                  | Analytical Chemistry Lab. | 0 6 2 |
|                        | Hum./Sci. electives | 3 0 3 | CM 177                  | Physical Chemistry Lab. | 3 0 3 |
|                        | Techin. Elective | 3 | CM 504                  | Chem. Lab. Safety | 1 0 1 |
|                        | Electives | 3 |                        | Hum./Sci. electives | 3 0 3 |

**Senior Year**

| CM 109                  | Inorganic Chemistry Lab. | 0 3 1 | CM 392-394                | Thesis | 6 0 3 |
| CM 175                  | Adv. Physical Chemistry | 4 0 4 |                        | Electives | 4 0 3 |
| CM 390-399 Bachelor's Thesis | 4 | |                        | Electives | 3 0 3 |

**BIOCHEMISTRY OPTION**

Freshman and sophomore courses as above.

**Junior Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
<td><strong>Cl. Lab. Cr.</strong></td>
<td><strong>No.</strong></td>
</tr>
<tr>
<td>LS 105</td>
<td>Biology I</td>
<td>3 0 3</td>
<td>LS 106</td>
</tr>
<tr>
<td>LS 115</td>
<td>General Biology Lab. I</td>
<td>1 3 2</td>
<td>LS 116</td>
</tr>
<tr>
<td>CM 118</td>
<td>Chemical Equilibria</td>
<td>2½ 5 4</td>
<td>CM 177</td>
</tr>
<tr>
<td>CM 162</td>
<td>Physical Chemistry II</td>
<td>3 0 3</td>
<td>CM 202</td>
</tr>
<tr>
<td>CM 201</td>
<td>Biochemistry I</td>
<td>3 0 3</td>
<td>CM 204</td>
</tr>
<tr>
<td>CM 501</td>
<td>Chemical Literature</td>
<td>1 0 1</td>
<td>CM 504</td>
</tr>
</tbody>
</table>

**Senior Year**

| CM 109                  | Inorganic Chemistry Lab. | 0 3 1 | CM 119                  | Analytical Chemistry | 3 0 3 |
| CM 120                  | Analytical Chemistry Lab. | 3 0 3 | CM 392-394                | Thesis | 6 0 3 |
| CM 390-399 Bachelor's Thesis | 4 | |                        | Electives | 3 0 3 |

Total credits required for graduation: 128
The department does not grant transfer credits for students who, while registered at Polytechnic, take chemistry courses at other schools.

In addition, the student is strongly urged to select an area of concentration (such as literature, communications, the arts or philosophy and comparative religion in the Department of Humanities, or political science, economics, history, anthropology or psychology in the Department of Social Sciences) and to elect two or three courses in this concentration, in consultation with the departmental adviser. A modern language may be chosen as a suitable concentration, but a student without prior knowledge of the language must plan to devote at least 12 credit hours to the subject.*

For the remaining credits in the humanities/social sciences requirement, the student should select courses in areas other than that of the concentration. Additional courses in the humanities and social sciences may be taken as free electives.

CM 201, CM 502 or a graduate course may be used as the advanced chemistry course. Students with a strong interest in mathematics may substitute MA 111-114 for MA 101-104.

Students with a special interest in biochemistry may eliminate CM 175 and the technical elective but must include the following: LS 105-106, LS 115-116, CM 201-202 and CM 204. It is recommended that LS 105-106, LS 115-116 be taken in the junior year by deferring the necessary credits of humanities/social sciences. The requirement for an advanced chemistry course is waived for students taking the biochemistry option.

All laboratory courses in chemistry require a breakage deposit.

The department does not usually grant transfer credits for students who, while registered at Polytechnic, take chemistry courses at other schools.

*To graduate, the student must demonstrate a knowledge of French, German or Russian equivalent to a fourth semester course. This may be done by passing the appropriate course or by passing a special examination administered by the humanities department.

TEACHING CERTIFICATION

Students wishing to obtain certification for teaching in the public schools of the New York City area may take education courses off campus and receive credit at Polytechnic for these courses as free electives. Approval for courses to be taken at another college must be obtained in advance from the major department and the academic dean.

GRADUATE STUDY

Admission to graduate study in chemistry requires a sound foundation in mathematics, physics and chemistry. College preparation should include at least four semesters of mathematics, two semesters of physics and chemistry (analytical, inorganic, organic and physical). In addition, it is desirable for a student to have had differential equations, atomic and nuclear physics, and two years of German, Russian or French. Chemistry graduate students cannot take CM 500 courses for graduate credit.

REQUIREMENTS FOR THE MASTER'S DEGREE

Chemistry

A total of 36 units past the bachelor's degree is required with an overall grade point average of B (3.0) or better in all courses (exclusive of thesis research) submitted for the master's degree. Programs must include the following core courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 601</td>
<td>inorganic Chemistry</td>
<td>4½</td>
</tr>
<tr>
<td>CM 703</td>
<td>Chemical Physics</td>
<td>4½</td>
</tr>
<tr>
<td>CM 802</td>
<td>Applied Spectroscopy</td>
<td>4½</td>
</tr>
<tr>
<td>CM 903</td>
<td>Advanced Organic Chemistry</td>
<td>4½</td>
</tr>
</tbody>
</table>

Students may elect research and a thesis (12 units). An oral defense of the thesis is held after the typed thesis has been submitted. A grade of A or B in thesis research is required.

Students not electing the thesis are required to take 3-6 units of guided studies with submission of a written report (CM 871-872).

Students in the master's program must participate in seminar for two semesters (CM 973-974); those electing no thesis must present at least one lecture to the seminar group.

All master's students must take CM 504, Chemical Laboratory Safety.

Additional requirements not measured in units are:

Demonstration of competence in one acceptable foreign language: in general, German, Russian or French. Students whose native language is not English must also demonstrate competence in English.

Continuous attendance at departmental colloquia.
Industrial Chemistry

The Department of Chemistry offers a master of science in industrial chemistry. Students electing this program are required to take the following courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 950</td>
<td>Industrial and Engineering Chemistry I, II</td>
<td>6</td>
</tr>
<tr>
<td>MG 600</td>
<td>Management Process</td>
<td>3</td>
</tr>
<tr>
<td>MG 895</td>
<td>Management of Innovation, Technological Change, Research and Development</td>
<td>3</td>
</tr>
<tr>
<td>CM 760</td>
<td>Minicomputer Instrumentation for Scientific Research</td>
<td>3</td>
</tr>
<tr>
<td>or</td>
<td>MA 531 Applied Mathematics for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>CM 955</td>
<td>Project in Industrial Chemistry</td>
<td>3-6</td>
</tr>
<tr>
<td>CM 504</td>
<td>Chemical Laboratory Safety</td>
<td>0</td>
</tr>
</tbody>
</table>

At least 12-15 units must be taken from graduate courses in chemistry numbered above 600.

The remaining units are to be chosen from the following list and from other graduate courses in chemistry:

| SS 672 | Technological Forecasting                    | 3     |
| CH 915-916 | Introduction to Polymeric Materials I, II | each 3 |
| CH 921 | Polymer Processing                           | 3     |
| HU 605 | Technical Writing                            | 3     |
| CM 502 | Environmental Chemistry                      | 3     |

REQUIREMENTS FOR THE DOCTOR'S DEGREE

Formal admission to the doctoral program requires passing a set of qualifying examinations at the level of the bachelor's degree in chemistry.

A total of 90 units past the baccalaureate degree level is required. A grade point average of B or better is mandatory in all courses (not including dissertation research) submitted for the Ph.D. degree, and a grade of A or B is required for the dissertation. The program includes the following courses, the first four in which the student must have at least a B average:

<table>
<thead>
<tr>
<th>Course</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 601</td>
<td>Inorganic Chemistry</td>
<td>4½</td>
</tr>
<tr>
<td>CM 703</td>
<td>Chemical Physics I—Quantum Structure of Molecules</td>
<td>4½</td>
</tr>
<tr>
<td>CM 704</td>
<td>Chemical Physics II—Thermodynamics and Statistics</td>
<td>4½</td>
</tr>
<tr>
<td>CM 802</td>
<td>Applied Spectroscopy</td>
<td>4½</td>
</tr>
<tr>
<td>CM 903</td>
<td>Organic Chemistry I—Molecular Structure and Bonding</td>
<td>4½</td>
</tr>
<tr>
<td>CM 904</td>
<td>Organic Chemistry II— Reactivity</td>
<td>4½</td>
</tr>
</tbody>
</table>

2. A major. 12
3. A minor. 7½
4. Participation in seminar for four semesters, twice as a lecturer. 5
5. Research presented in a dissertation. 6
6. Demonstration of competence, at a level higher than that required for the master's degree, in an acceptable foreign language. Students whose native language is not English must also demonstrate competence in English.
7. By the end of the second year, the student is required to pass a preliminary examination, administered by the Guidance Committee, which may consist of written and oral portions.
8. Attendance at seminars and colloquia for the duration of research.
9. Passage of a final oral examination. The final oral examination will take place after the members of the Guidance Committee have read the dissertation in typed, unbound form.

All students in the doctoral program will be awarded the master of science degree upon satisfactory completion with a grade of A or B in course requirements equivalent to the above, in addition to 12 units of research toward the doctoral dissertation as certified by the chairman of the Guidance Committee. On proper application to the graduate affairs office and after completion of the preliminary examinations, the student will be certified as having earned the master of science degree.

All students should consult the current departmental bulletin, Information for Chemistry Graduate Students for most recent guidelines for Ph.D. students.

UNDERGRADUATE COURSES

CM 001 Principles of Chemistry I+ 2½-1½:3
Basic principles of chemistry with emphasis on historical origins. States of matter, modern concepts of atomic and molecular behavior in relation to chemical processes. Introduction to chemical equilibrium and kinetics. Selected laboratory experiments. For students majoring in humanities or social sciences. Lab fee required.

CM 002 Principles of Chemistry II+ 2½-1½:3
Basic principles of descriptive inorganic and organic chemistry with applications to electrochemistry, polymer chemistry, biochemistry. Selected laboratory experiments and introduction to quantitative laboratory techniques. For students majoring in humanities or social sciences. Lab fee required. Prerequisites: CM 001.

* Includes required courses.
CM 101 General Chemistry I 2 și 0:2 și
Chemical conservation laws, states of matter, acid-base and oxidation-reduction theory, introduction to chemical thermodynamics and chemical equilibria, electro-chemistry, kinetics.

CM 102 General Chemistry II 2 și 0:2 și
Atomic and molecular structure, periodic table, descriptive inorganic chemistry, introduction to organic chemistry including polymer and biochemistry, and photochemistry. Prerequisites: CM 101, CM 111.

CM 108 Inorganic Chemistry 3:0:3
Atomic structure of elements as basis for periodic classification. Descriptive chemistry of elements and their compounds. Theory of chemical bonds and introduction to coordination chemistry. Prerequisites: CM 102, CM 112 and CM 161.

CM 109 Inorganic Chemistry Laboratory 0:3:1
Laboratory experiments introducing techniques employed in preparation and characterization of inorganic substances. Lab fee required. Prerequisite: CM 102, CM 112 and CM 161.

CM 111 General Chemistry Laboratory I 0:1:½
Introduction to chemical laboratory procedures. Laboratory associated with the lecture course, CM 101. Lab fee required.

CM 112 General Chemistry Laboratory II 0:1:½
Laboratory experiments in qualitative analysis to be taken in conjunction with CM 102. Lab fee required. Prerequisites: CM 101, CM 111.

CM 118 Chemical Equilibria 2 și 5:4
Equilibria in homogeneous and heterogeneous chemical processes. Applications of equilibrium concepts and data to analytical and physical chemistry. Theory of solutions and other analytical processes. Thermodynamic and chemical interpretation of equilibrium data. Separation techniques. Lab fee required. Prerequisites: CM 161-162.

CM 119 Instrumental Methods in Analytical Chemistry 3:0:3
Theory and application of instrumental techniques in modern analytical chemistry, including chromatography, spectroscopy (ultraviolet absorption, fluorescence, infrared, Raman, nuclear magnetic resonance, electron spin resonance, atomic absorption and emission), X-ray absorption, fluorescence and diffraction, mass spectrometry, thermal methods, etc. Prerequisites: CM 161-162.

CM 120 Analytical Chemistry Laboratory 0:6:2
Techniques described in CM 119 applied to various chemical problems stressing physicochemical interpretation of data obtained. Lab fee required. Prerequisites: CM 118 and CM 161-162. Co/Prerequisite: CM 119.

CM 122 Organic Chemistry I 3:0:3
Chemistry of organic molecules; structure, nomenclature, properties and reactions of carbon compounds with emphasis on aliphatic compounds. Introduction to reaction mechanisms, stereochemistry, spectroscopic methods. Prerequisites: CM 102 and CM 112.

CM 123 Organic Chemistry II 3:0:3
Continuation of CM 122 with emphasis on aromatic chemistry, condensation reactions, carbohydrates, amino acids and synthetic polymers. Prerequisite: CM 122.

CM 124 Organic Chemistry Laboratory I ½:5:2
Laboratory methods for preparation, isolation and purification of typical organic compounds. Experiments chosen to illustrate basic techniques. Lab fee required. Co/Prerequisite: CM 122.

CM 125 Organic Chemistry Laboratory II ½:5:2
Laboratory methods for preparation, purification, characterization and identification of organic compounds by chemical and physical means. Introduction to use instrumental methods of analysis and identification. Lab fee required. Prerequisite: CM 124. Co/Prerequisite: CM 123.

CM 161 Physical Chemistry I 3:0:3
Chemical thermodynamics (macroscopic and molecular approach) with applications to solutions, phase and chemical equilibria, kinetic theory. Prerequisites: CM 102, CM 112, MA 103 and PH 103.

CM 162 Physical Chemistry II 3:0:3

CM 164 Physical Chemistry of Living Systems 3:0:3
Basic concepts of physical chemistry illustrated by examples of physiological significance. Thermodynamics, chemical equilibria, equilibria in coupled processes, electrochemistry, diffusion, molecular weight of molecules, spectroscopy, reaction kinetics and use of isotopes. This course may not be used in fulfillment of physical chemistry requirements for the B.S. in chemistry. Strong students may, with an instructor's permission, present this course as a prerequisite for CM 201. Prerequisites: CM 102, CM 112, MA 103 and PH 103.

CM 175 Physical Chemistry III* 4:0:4
Atomic and molecular aspects of physical chemistry. Quantum chemical statistical description of matter with applications to molecular spectroscopy, binding and structure. Prerequisite: MA 104. Co/Prerequisite: CM 162.

CM 177 Physical Chemistry Laboratory ½:5:2
Experimental methods of physical chemistry. Chemical kinetics, thermodynamics, electrochemistry, molecular spectroscopy, high vacuum, instrumental techniques. Computer analysis of experimental data. Lab fee required. Prerequisites: CM 118 and CM 162.

CM 201 Biochemistry I 3:0:3
Survey of modern biochemistry with emphasis on currently active areas of research. Structure-function relationships in proteins and nucleic acids, Enzymes and their mechanisms of action, bioenergetic principles and energy production. Biochemical theory and techniques. Prerequisite: CM 123, CM 125 and CM 161, or instructor's permission.

CM 202 Biochemistry II 3:0:3
Continuation of Biochemistry I. Important principles of intermediary metabolism, energetics, membrane transport, replication of DNA and RNA, protein synthesis, hormonal regulation, cancer. Prerequisites: CM 201 and CM 162, or instructor's permission.

CM 204 Biochemistry Laboratory ½:5:2
Laboratory experiments illustrating techniques for isolating and characterizing biological macromolecules, analyzing enzyme kinetics and elucidating metabolic pathways. Lab fee required. Co/Prerequisite: CM 201.

CM 390-394 Bachelor’s Thesis in Chemistry 2 credits
Original investigation by student under guidance of a departmental staff member. Careful literature search required before inception of laboratory work, continued reference to chemical literature expected, and active participation in conferences and seminars scheduled as work progresses. Student
required to give oral resume of work before at least two members of chemistry faculty. Full-time students are expected to register for 10 credits of thesis during senior year. Re-registration beyond CM 384, each semester, 2-credit charge for evening students, 4-credit charge for day students. Research (lab) fee required. Co/Prerequisites: CM 501 and CM 504.

CM 501† Chemical Literature 1:0:1
Program of lectures, exercises and discussion designed to familiarize students with the chemical literature. Students may emphasize topics related to bachelor's thesis. Prerequisites: CM 123, CM 125 and CM 162.

CM 502† Environmental Chemistry* 3:0:3
Chemical reactions important in maintaining the ecosystem and in pollution. Genesis analysis and removal of pollutants. Effects of chemical pollutants on health of industrial workers and the general population. Prerequisites: CM 122, CM 124 and CM 161 or CM 164 or instructor's permission.

CM 503† Organic Chemistry for Bioengineers 2:0:2
Introductory course in organic chemistry for engineering students entering bioengineering program. Structure and reactions of organic compounds; organic molecules of biological significance. Prerequisites: CM 102 and CM 112 or equivalent.

CM 504† Chemical Laboratory Safety 1:0:1
A discussion of problems of health and safety arising in chemical laboratories. How to work safely with dangerous chemicals. This course must be completed by both graduate and undergraduate chemistry students before they undertake laboratory research.

GRADUATE COURSES

INORGANIC CHEMISTRY

CM 601† Inorganic Chemistry 3:0:4½
Theories of bonding of inorganic compounds. Introduction to group theory as applied to molecular orbital and ligand field theory. Spectra of inorganic compounds; Nonaqueous solvents, introduction to transition metal chemistry. Required of all candidates for Ph.D. degree in chemistry.

CM 614-619 Advanced Topics in Inorganic Chemistry* each 2½:0:3
Selections from following topics may be offered: physical and synthetic methods in inorganic chemistry, organometallic chemistry, chemistry of solids, chemistry of coordination compounds, mechanisms of inorganic reactions, chemistry of non-metals, inorganic polymers, chemistry of representative elements, bonding theory. Prerequisite: CM 601 and advisor's approval.

PHYSICAL CHEMISTRY

CM 704 Chemical Physics I 3:0:4½

CM 705 Chemical Physics II 3:0:4½

CM 712 Research Instrumentation* 2½:5:6
Laboratory course in electronics for students planning to use electronic instrumentation in research. Malmstadt/Enke Instrumentation Laboratory used. Power supplies, vacuum tube and solid state amplifiers; oscilloscopes, servo systems, operational amplifiers, digital instrumentation. Prerequisite: advisor's approval.

Also listed under CM 841, BE 622 and SA 605

CM 715 Kinetics of Chemical Reactions* 2½:0:3
Methods and results of investigation of rates and mechanisms of reaction in gases and in solution. Collision and transition state theories of reaction rates. Prerequisite: CM 705.

CM 719 Valence and Molecular Structure* 2½:0:3
Descriptive exposition of application of quantum mechanics to problems of chemical bonding and molecular structure. Various quantum mechanical theories of valence, their applicabilities and limitations. Prerequisite: CM 705.

CM 717* Electrochemistry* 2½:0:3

CM 721 Quantum Mechanics for Chemists* 3½:0:4½
Principles of quantum mechanics quantitatively developed. Comparison of various approaches. Most important approximation methods useful for application of theory to many problems in chemistry and physics. Detailed discussion of several applications to some basic problems. Required of all Ph.D. candidates with major in physical chemistry. Prerequisites: CM 705, PH 601 and PH 602.

CM 722 Statistical Mechanics for Chemists* 3½:0:4½
Classical and quantum statistical mechanics systematically developed and applied to calculation of thermodynamic properties of various states of matter from knowledge of structure of atoms and molecules and their forces of interaction. Required of all Ph.D. candidates with major in physical chemistry. Prerequisite: CM 721.

CM 730-731 Group Theory and Its Applications I, II* each 2½:0:3
Group theory and its applications to various problems in chemistry and physics. Abstract group theory; group representations; finite and continuous groups. Applications to crystallography, valence theory, interpretation of atomic and molecular spectra, crystal field theory, energy band theory of solids, crystal symmetry and physical properties. CM 730 prerequisite: instructor's permission. CM 731 prerequisite: CM 730.

CM 750 Special Topics in Physical Chemistry* 2½:0:3
Advanced or specialized topics in physical chemistry presented at irregular intervals.

CM 760† Microcomputer instrumentation for Scientific Research 1½:2:3
Fundamentals of digital electronics and microcomputers, computer-automated laboratory instrumentation, programming and interfacing required for data acquisition and control in scientific research, experiments with microcomputers and with laboratory apparatus interfaced directly to microcomputers. Lab fee required. Prerequisite: instructor's permission.

Also listed under PH 812 and BE 823.
POLYMER CHEMISTRY

CM 771 Introductory Polymer Chemistry 2 1/2:0:3
Synthesis of polymers by step-reaction and addition polymerization, copolymerization, formation of three dimensional networks, block and graft polymers, polymer degradation, characterization of polymers in solution, rubber elasticity, polymer crystallization, spectroscopic techniques for polymer study, properties of commercial polymers. Prerequisites: CM 123, CM 125 and CM 152.

CM 772 Synthesis of High Polymers 2 1/2:0:3

CM 781 Solution Properties of High Polymers 2 1/2:0:3
Application of osmometry, light scattering, equilibrium ultracentrifugation, electron microscopy, viscosity, diffusion, ultracentrifuge sedimentation, flow birefringence, polarimetry, spectroscopy and other techniques to the characterization of dissolved macromolecules. Properties of polyelectrolytes, association in solutions containing macromolecules and reaction kinetics in macromolecular solutions also discussed. The course designed to cover both synthetic and biological macromolecules. Prerequisites: CM 161, CM 162 and CM 772 or CM 783.

CM 782 Macromolecules in the Solid State* 2 1/2:0:3
Crystalline-amorphous systems, thermodynamics of crystallization, defect structures, morphology of polymer crystals. Characterization of polymeric solids by X-ray and electron diffraction, potential energy calculations, electron microscopy, absorption spectroscopy and nuclear magnetic resonance. Electrical and optical properties of polymer solids. Prerequisite: CM 771.

CM 783 Laboratory Methods in Polymer Chemistry 0:5:3
Experiments on free radical condensation, ionic and copolymerization, absorption, and NMR spectroscopy, intrinsic viscosity, light scattering, gel permeation chromatography, X-ray diffraction, thermogravimetric analysis, differential scanning calorimetry, dilatometry, concentrated solution viscosity, and other aspects of polymer synthesis and characterization. Lab fee required. Prerequisite: CM 771.

CM 785 Special Topics in Polymer Chemistry 2 1/2:0:3
Presentation at intervals of various advanced or specialized topics in polymer chemistry.

ORGANIC CHEMISTRY

CM 903 Organic Chemistry I 3 1/4:0:4 1/2
Molecular structure and bonding. Stereochmnical and conformational principles. Theories of bonding and the physical parameters of stable and reactive molecular states. Applications in biochemistry and polymer chemistry. Prerequisites: undergraduate physical chemistry and organic chemistry.

CM 904 Organic Chemistry II 3 1/4:0:4 1/2
Reactivity of molecules. The methods of mechanistic study of reaction pathways. Important reactions of organic and organometallic chemistry. Introduction to synthesis and applications in living systems and in polymer reactions. Prerequisite: CM 903.

CM 905 Spectroscopy of Organic Molecules 2 1/4:0:3
Application of spectroscopy to organic chemistry with emphasis on interpretation of vibrational, electronic, mass and magnetic resonance spectra of organic molecules including polymers. Prerequisite: CM 123, and CM 125 or equivalent.

CM 915 Topics in Physical Organic Chemistry* 2 1/2:0:3
Quantitative aspects of structural, electronic and medium effects in organic reactions; theoretical approaches to organic mechanisms, stereochemistry. Prerequisite: CM 903.

CM 920 Current Aspects of Organic Synthesis* 2 1/2:0:3
Approaches to synthesis of organic molecules. Stereoselective and stereospecific reactions. Examples drawn from naturally occurring and theoretically interesting molecules. Prerequisite: CM 903.

CM 921-933 Advanced Topics in Organic Chemistry* 2 1/2:0:3
Selections from the following topics will be offered at regular intervals: organometallic chemistry, photochemistry, heteroatom chemistry and natural products. Prerequisite: CM 903, 903.

CM 940 Special Topics in Organic Chemistry* 2 1/2:0:0
Selected topics of current importance in organic chemistry. Prerequisite: CM 903.

BIOCHEMISTRY

CM 941-942 Biochemistry I, II each 2 1/2:0:3

CM 943-946 Advanced Topics in Biochemistry* 2 1/2:0:3
Selections from the following topics offered at irregular intervals: protein and nucleic acid chemistry, intermediary metabolism and metabolic regulation. Prerequisite: CM 941 or consent of instructor.

CM 947 Biochemical Techniques 1 1/2:0:3
CM 948 Epidemiology of Environmental Health 3:0:3
An introductory course on methodology, meaning and scope of epidemiology. Elements of biostatistics, study design, data collection. Emphasis on the scientific appraisal of the patterns of health and disease in environmental and occupational exposure to toxic chemicals.

INDUSTRIAL CHEMISTRY

CM 950-951 Industrial and Engineering Chemistry I, II each 3:0:3
Discussion of the chemical process industries, emphasizing basic chemical and physical principles, as well as the economic feasibility of individual processes, to provide a chemical engineering background for chemists. Emphasis on stoichiometry, thermodynamic considerations, and unit operations such as absorption, extraction and distillation, as well as fluid dynamics and heat transfer. Natural resource analysis and recycling. Slagwise and continuous contact equipment and flow sheet analysis. Chemical plant design and chemical economics. Individual reading and discussion of selected papers in chemical process technology. Prerequisite: B.S. degree in chemistry or allied field or permission of instructor.

CM 955 Project in Industrial Chemistry as arranged
Directed study or supervised reading and/or experimental work in advanced area of chemistry and chemical technology. Conferences scheduled. Candidates for this M.S. degree program are required to submit four unbound copies of a typewritten project report and present an oral summary to advisers on or before the seventh Wednesday prior to graduation. Prerequisite: B.S. in chemistry or allied field or permission of instructor.

GENERAL COURSES

CM 871-872 Guided Studies in Chemistry as arranged
Directed study or supervised readings in advanced areas of chemistry. Registration by consent of department head.

CM 971-972 Chemical Colloquium 0
Meetings of the members of the department staff, invited guests and qualified students to study recent developments in chemistry. Required each year of all students in graduate degree status majoring in chemistry and for two years of doctoral matriculants in other departments with minor in any field of chemistry. Seminar fee required.

CM 973-976 Seminar in Chemistry each 1½ units
Chemical topics of current interest presented by participating students, staff, outside lecturers. Two semesters required of all master's candidates and four semesters of all doctoral candidates.

CM 995-996 Seminar in Chemical Physics* each 1½
Topical subjects, problems, current research in chemical physics presented by participants, staff, outside lecturers. Required of all master's and doctoral candidates in chemical physics.

CM 998 Research in Chemistry 3 units
Original research, which may serve as the basis for the master's degree. Also to be taken by Ph.D. candidates prior to completion of the Ph.D. preliminary examination in chemistry. Minimum research registration requirements for the master's degree: 12 units. Registration for research required each semester consecutively until student has completed adequate research project and acceptable thesis and has passed required oral examination. Number of research credits registered for each semester shall reflect realistically time to be devoted to research. A maximum of 6 units may be counted toward the Ph.D. in chemistry. Research fee. Prerequisites: for M.S. candidates, degree status and consent of graduate adviser and thesis director and CM 504T.

CM 999 Research in Chemistry 3 units
Original experimental or theoretical research (undertaken under guidance of a chemistry faculty member), which may serve as basis for degree of doctor of philosophy. Chemical physics major with thesis advisers in Department of Physics should register for PH 791-796 and PH 981-993. Minimum research registration requirements for the degree: for holders of M.S. based on research and thesis acceptable to department, 33 units; for other students, 45 units. Registration for research required each semester consecutively until student has completed adequate research project and acceptable thesis and has passed required oral examination. Number of research credits registered for each semester shall reflect realistically time to be devoted to research. Research fee required. Prerequisites: completion of Ph.D. preliminary examination in chemistry and consent of thesis director and CM 504T.

LIFE SCIENCES PROGRAMS

In recent years, Polytechnic has developed strengths in the life sciences that complement those in its long-established teaching and research programs in engineering and the physical sciences. Specific curricula and areas of concentration, including premedicine, biology, biochemistry, environmental sciences, bioengineering and laboratory techniques are designed to offer exceptional preparation for medical, dental and other professional careers, as well as for graduate study in the life sciences and a wide variety of interdisciplinary programs. Qualified students have extensive opportunities to participate in faculty research programs, special projects and independent study.

Students have the flexibility of selecting a program of study best suited to their individual needs:

1. A biology curriculum, essential for graduate studies and a career in biology.

2. An interdisciplinary, premedicine curriculum, preparing for a professional career in the health-related sciences.

3. A career-oriented curriculum to provide skills required for laboratory work in a research, hospital or industrial setting.

4. A life sciences-computer curriculum, in which computer technology may be applied to a career in health-related fields. This option is available to students achieving a bachelor of science in life sciences, with a strong concentration in computers, at the end of four years. With an additional year, the student can fulfill the requirements for a master's degree in computer science.

5. A life sciences-electrical engineering curriculum, to prepare for careers in which engineering technology may be applied to studies of living systems. This curriculum in life science gives the student in-depth exposure to electrical engineering, equivalent to that of a double major, and leads to a bachelor of science in life sciences.
The student can fulfill the requirements for a master's degree in electrical engineering with only one additional year of study.

**GENERAL REQUIREMENTS FOR ALL CURRICULA**

Part of the biology requirement may be fulfilled by biochemistry courses, CM 201, 202, 204. Technical electives must include one from a group including electronics, living system analysis or research instrumentation, e.g., BE 201-202, CH 841, EE 370 or IE 314. A second course must be in the area of computers. Other technical electives should be chosen in consultation with the life sciences advisor. A total of 36 credits in humanities, social sciences and modern language is required in all curricula except the life sciences-electrical engineering program. Of these, a minimum of 15 credits are required in humanities, including HU 101, HU 200 and a course in technical writing. A minimum of 15 credits are also required in social sciences, including SS 104 and a nine-credit concentration in a specific area of study. Six credits of language are required in continuation of three years of a high school language. Four years of a language in high school eliminates this requirement. Students with fewer than three years of a modern language are required to take two years of language. Advanced language courses in literature may be used to fulfill a literature concentration. IS 140-141 can be substituted for HU 200 and SS 104.

**Biology** is concerned with the study of life in all of its manifestations—from the simple to the complex, from the invisible to the macroscopic and from the virus to the human. To move beyond the definitions of life to the understanding of life's fundamental nature, one must examine the characteristics of living systems, including growth, heredity and reproduction, metabolism, energy production and utilization, responsiveness, and locomotion. Further, one must probe both the structure and function of living matter at the molecular, cellular and organismal levels. An understanding of structure and function leads to a generalization of the principles involved and an understanding of how living systems operate. Indeed, viewpoints and techniques of biology, chemistry and physics all contribute to our study and understanding of living systems at all levels.

Students majoring in the life sciences are required to complete courses in biology, chemistry, physics and mathematics.

**Pre-medicine** curriculum is designed to prepare the student to meet the challenges of the life sciences, medicine and the medically oriented sciences. It provides a well-rounded program in the humanities and social sciences as well as a substantial preparation in the basic sciences. The individual student may shape a course of study so as to build a firm foundation for professional study in medicine, dentistry, osteopathy, veterinary medicine, optometry, podiatry and pharmacy.

**Career-oriented curriculum** permits the student to develop expertise in a variety of laboratory skills such as microscopy, chromatography, electrophoresis, centrifugation and radioisotopic methods, etc., which are required in research, hospitals and the industrial sectors. Within the curriculum, students select a subspecialty area, such as management, technical writing, environmental biology or bioengineering, which further enhances the opportunity to achieve meaningful employment on graduation or to complete successfully an M.S. in one additional year, as well as to continue with graduate or professional schools.

**Life Sciences—Computer Science** is a five-year inter-disciplinary program designed for students interested in the utilization of computer sciences in a career in the life sciences. Participants achieve a bachelor's degree in life sciences after four years and a master's degree in computer science with but one additional year. The four-year undergraduate curriculum in life sciences includes in-depth studies in biology, a strong concentration in computer science and demonstrates how computers can be utilized in the analysis and understanding of phenomena in living systems. Consult the computer science section of this catalog for details of the master's program in computer science. A 2.7 grade point average in technical subjects will automatically admit the student into the M.S. in computer science program without deficiencies.

See M.S. curricula under course requirements for M.S. in electrical engineering or computer science.

**Life Sciences—Electrical Engineering**. A five-year interdisciplinary program is offered that leads to the degree of bachelor of science in life sciences, with a concentration in electrical engineering after four years and a master of sciences in electrical engineering with one additional year. This life sciences program includes a strong orientation in electronic instrumentation, computer programming, control systems, electromagnetics and systems analysis which permits the student to complete a master's degree in electrical engineering within one additional year beyond the B.S. in life sciences. In addition to providing the necessary prerequisites for entry into advanced study in life sciences, it offers in-depth study of electrical systems. This course of study involves 156 credits. It is thus a synthesis of two degree programs and provides health-related scientists and practitioners with a new dimension and outlook in the definition of the function of living systems. A 2.7 grade point average in technical subjects will guarantee admission into the M.S. in electrical engineering program without undergraduate deficiencies. Consult the graduate electrical engineering section of this catalog for details of the master's degree curriculum.
Typical Program for Bachelor of Science Degree in Life Sciences (Biology Curriculum)

**Freshman Year**

<table>
<thead>
<tr>
<th>Semester</th>
<th>No.</th>
<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
<th>No.</th>
<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tr>
<td>First</td>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2½</td>
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<td>CM 102</td>
<td>General Chemistry II</td>
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<td></td>
<td>LS 105</td>
<td>General Biology I</td>
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<td>LS 106</td>
<td>General Biology II</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Second</td>
<td>LS 103</td>
<td>General Biology I</td>
<td>1</td>
<td>3</td>
<td>LS 116</td>
<td>General Biology Lab. II</td>
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| Hours/Week | 15 |

**Sophomore Year**

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<tr>
<th>Semester</th>
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<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tbody>
<tr>
<td></td>
<td>LS 103</td>
<td>Developmental Biology I</td>
<td>3</td>
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<td>LS 104</td>
<td>Developmental Biology II</td>
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<td>MA 200</td>
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<td>MA 102</td>
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**Junior Year**

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<th>Lab.</th>
<th>Cr.</th>
<th>No.</th>
<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LS 132</td>
<td>Cell Physiology</td>
<td>3</td>
<td>3</td>
<td>LS 112</td>
<td>Fundamentals of Genetics</td>
<td>3</td>
<td>3</td>
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<tr>
<td></td>
<td>CM 124</td>
<td>Organic Chemistry Lab. I</td>
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<td>5</td>
<td>CM 125</td>
<td>Organic Chemistry Lab. II</td>
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<tr>
<td></td>
<td>HU 101</td>
<td>Electives</td>
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<td>0</td>
<td>HU 200</td>
<td>Electives</td>
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<td>0</td>
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**Senior Year**

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<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
<th>No.</th>
<th>Subject Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tr>
<td></td>
<td>CM 118</td>
<td>Chemical Equilibria</td>
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<td>5</td>
<td>LS 140</td>
<td>Environmental Biology</td>
<td>2½</td>
<td>1½</td>
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<tr>
<td></td>
<td>LS 130</td>
<td>Organismal Physiology</td>
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<td>3</td>
<td>MA 101</td>
<td>Calculus I</td>
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<tr>
<td></td>
<td>HU 101</td>
<td>Electives</td>
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<td>0</td>
<td>HU 200</td>
<td>Electives</td>
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**Total credits required for graduation:** 128

Curriculum for other Life Sciences Programs:

**Pre-Medicine**

Students are not required to take LS 103, 104, 112, 130, 132, 140. Electives, selected in consultation with adviser, are substituted.

**Career-Oriented**

Students are not required to take LS 103, 104, 112, 115, 116, 132, 140, CM 118, 164. Courses LS 121, 155, 156, 160, and CS 111, plus additional electives are substituted.

**Life Sciences-Computer Science**

Students are not required to take LS 103, 104, 112, 130, 132, 140, CM 118, 164. Course requirements for this program include IE 314, and computer science courses CS 203, 204, 205, 111, 236, 237, 257 and 295, plus selected electives.

**Life Sciences - Electrical Engineering**

Students are not required to take courses LS 103, 104, 112, 130, 132, 140, CM 118, 164. Additional required courses include MA 103, 104, CS 111, LS 305, 306, BE 201, and electrical engineering courses EE 101, 102, 103, 111, 112, 161, 193, 194, and 195, plus selected electives.

All students in the Life Sciences programs should select their programs and courses in consultation with a departmental adviser.
UNDERGRADUATE COURSES

LS 103-104 Developmental Biology I, II each 3:3:4

LS 105-106 General Biology I, II each 3:3:3

LS 112 Fundamentals of Genetics 3:3:3
Fundamental aspects of the genetics of bacteria, viruses and higher organisms. Emphasis is placed on both the genetic biochemical analyses of gene replication, recombination, and gene expression. Comparisons of prokaryotic and eukaryotic genetics and regulation as well as topics in human genetics are included. Laboratory techniques used in the biological and biochemical study of genetic phenomena in prokaryotes, eukaryotes and their viruses. Emphasis placed on modern approaches to genetic research. Lab fee required. Prerequisites: LS 106, 116. Co/Prerequisite: CM 122.

LS 115-116 General Biology Laboratory I, II 1:2:2
Recitations in relationship to laboratory experiments will include discussions of such topics as; cell structure and function, chemical and physical characteristics of living things, unity and diversity of living things, genetics, development, homeostasis, integration and coordination, adaptation, evolution, ecology, and the biological basis of behavior. Lab fee required. Prerequisites: LS 106, 116. Co/Prerequisite: LS 105. LS 116 Co/Prerequisite: LS 106.

LS 120 Microbiology 3:3:3
Study of microbial organisms, especially bacteria and viruses. Microbial relationship to disease, infectious and immunologic processes. Mutation, transformation, transduction, induction and bioenergetic processes. Laboratory work: experimental analysis of microbial structure and physiology by biochemical and cytological means. Influence of environment on nutrition, enzymes and metabolism of representative microbial species. Lab fee required. Prerequisites: LS 106, 116 and CM 102, or instructor's permission.

LS 121 Clinical Microbiology 3:3:3
Lectures and laboratory exercises in microbial structure, culturing, growth, metabolism and control. Special emphasis on bacteria that cause infectious diseases, medical virology, and mycology, and serological testing procedures. Lab fee required. Prerequisites: LS 106, 116 or permission of the instructor.

LS 130 Physiology 3:3:4
Mechanisms involved in functional processes of cells and multicellular organisms including integration and control aspects. Membrane function, transport, excitation, conduction, contraction, luminescence. Lab fee required. Prerequisites: LS 106, LS 116, CM 102, CM 112 and PH 103.

LS 132 Cell Physiology 3:3:3
Analyses of chemical and physical mechanisms of cellular function. Molecular constituents of biological systems, enzymes and reaction rates; energetics and regulation of metabolic processes, membrane transport, contractility and irritability. Laboratory studies, examination of cellular components in terms of their functional activities (enzymes, oxidative phosphorylation, photosynthesis), kinetics of soluble and membrane-bound enzymes, membrane transport. Lab fee required. Prerequisites: LS 106, and LS 116. Co/Prerequisites: CM 123 and CM 164.

LS 140 Environmental Biology* 2:1/2:3
Study of interrelationships of organisms and their environments. Structure and dynamics within the ecosystem, including: biogeochemical cycles, energy, populations and food supply. The effects of pollution and technology as they influence alternatives. Economics, law and policy decisions in environmental management are considered. Knowledge of FORTRAN or similar language desirable. Lab fee required. Prerequisite: MA 104 or instructor's consent.

LS 151 Cell Biology 3:3:3
Analyses of the cell at all levels of organization to reveal its subcellular, macromolecular and molecular architecture. Topics include: microscopy, cell ultrastructure and function, motility, meiosis, the cell cycle, modes of membrane structure, chromosomes and mitochrondia, microfilaments and microtubules structure and function, cell-cell interactions and cell differentiation. Lab fee required. Prerequisite: LS 106 and LS 116 or permission of the instructor.

LS 155-156 Laboratory Techniques and Instrumentation in Biology each 1:3:4
Theory and practical applications of basic analytical laboratory procedures. The course will progress from basic skills such as solution preparation, pH measurements and volume and mass determinations to more sophisticated procedures such as: compositional analyses (protein, DNA, RNA, lipid and carbohydrate determinations), microscopy (light, phase contrast and fluorescence), electrophoresis (polyacrylamide gel and cellulose acetate), ultra centrifugation, chromatography (affin, ion-exchange and permeation), radiisotopic methods (labeling procedures, radioimmunoassays, autoradiography and liquid scintillation counting), tissue culture techniques, spectrophotometry (UV-visible, near-infrared and fluorescence). Lab fee required. Prerequisite: LS 106.

LS 180 Histological Techniques 3:3:4
The microscopic study of tissues and organs is presented as background for their visual recognition as well as that of specific cell types. The functional significance of variations and alterations of cell types is stressed. Laboratories are designed to familiarize the student with basic techniques including: fixation, dehydration, embedding, microtomy, slide preparation, staining and histochemistry. Lab fee required. Prerequisite: LS 106.

LS 200 Close Encounters of a Biological Kind* 2:1/1:3
Selected relevant topics may include chronic and acute health effects of physical and chemical environmental agents on biological systems, (lead, asbestos, food additives, contaminants, organ transplantation, nutrition, drug addiction, genetic engineering, euthanasia, human experimentation, abortion, human sexuality, battered persons. Laboratory: field trips and experimental learning in project form.

LS 300-304 Thesis in Biology each 2 credits
Independent work undertaken by students in biology under guidance of faculty members. Original investigation involves careful search of literature, with active participation in conferences and seminars as work progresses. Oral presentation of work before departmental staff and written thesis required. Lab fee required. Prerequisite: departmental advisor's approval.

LS 355-357 Senior Project in Life Sciences each 2 credits
Investigation of problem in biology under supervision of faculty member. Library research, experimental studies, written reports required. Lab fee required. Prerequisite: senior status or advisor's approval.
LS 308 Life Sciences Internship  2 credits
Supervised projects carried out in a hospital, community or industrial setting. Evaluated on basis of written and oral reports presented to faculty and outside project co-sponsors. Faculty conferences and visits required. Open to senior students on approval of departmental adviser. Prearranged experience provides student with significant exposure to relationships between theoretical information and practical applications. Prerequisite: senior status or adviser's approval.

LS 310 Seminar in Biology  1 credit
Selected topics of current interest to be presented by participating students, staff and outside lecturers. Prerequisites: LS 105 and LS 106.

GRADUATE COURSES

LS 561 Electron Microscopy†  1:9:4
Course oriented toward development of proficiency in electron microscopic techniques. Discussions and exercises in preparation of glass knives, fixation, dehydration and embedding of biological specimens. Ultra thin sectioning, staining, use of the transmission electron microscope, and introduction to photographic techniques. Lab fee required. Prerequisites: LS 106 and LS 110 or permission of the instructor.

LS 600 Neurophysiology*  2 ½:0:3
An in-depth discussion of basic nerve cell physiology covering such topics as the resting potential, sodium pump, action potential, synaptic mechanisms and local neuronal circuits. Prerequisite: LS 106 or BE 611.
Also listed under BE 692

LS 601 Topics in the Neurosciences*  2 ½:0:3
A review and in-depth discussion of various topics in the neurosciences. Typical topics will be neurotransmitters, motor control, developmental neurobiology, circadian rhythms, pain, neuronal modeling, neural correlates of control nervous system disorders, etc. Topics will vary from semester to semester and course may be taken for repeated credit. Prerequisites: LS 106, BE 611 or permission of instructor.
Also listed under BE 693

LS 700-701. Cytology I, II*  each 2 ½:0:3

LS 702 Cytology Laboratory*  0:4:2
Experimental analysis of cellular structure and functions. Preparation of cells for microscopy examined supplemented by demonstrations of special methods and of representative preparations. Light field, dark field, fluorescence, interference, polarizing and electron microscopy of cytoplasmic and nuclear components and of specialized cells. Lab fee required. Prerequisites: LS 700 and LS 701.

LS 900 Selected Topics in Biology*  2 ½:0:3
Presentation of significant topics in biology or related interdisciplinary areas. Topics may vary from year to year.

FACULTY

Yoshiyuki Okamoto, Professor of Organic Chemistry and Head, Department of Chemistry
B.S., Osaka University of Science and Engineering (Japan); Ph.D., Purdue University
Organic and polymer chemistry

Ephraim Banks, Professor of Inorganic Chemistry
B.S., CCNY, Ph.D., Polytechnic Institute of Brooklyn
Chemistry and physics of crystals, solid state reactions and phase transitions

F. Marshall Beringer, Professor of Organic Chemistry
B.S., Harvard University; M.S., Ph.D., Columbia University
Organocopper compounds, organic derivatives of polyvalent iodine, reactive intermediates

Bernard J. Bulkin, Professor of Chemistry, Vice President for Research and Graduate Affairs, Director of Institute of Imaging Sciences
B.S., Polytechnic Institute of Brooklyn; Ph.D., Purdue University
Infrared and Raman Spectroscopy, cell membranes, liquid crystals

L. Guy Donaruma, Professor of Polymer Chemistry and Provost
B.S., St. Lawrence University; Ph.D. Carnegie-Mellon University
Biologically active polymers, polymers for enhanced oil recovery, polymeric nitroso compound

Frederick Eirich, Distinguished Professor of Polymer Chemistry
Ph.D., University of Vienna
 Mechanical behavior of polymers, rheology, colloid chemistry, chemical evolution, biopolymers

Ernest M. Loebi, Professor of Physical Chemistry
M.S., Hebrew University; Ph.D., Columbia University
Theoretical chemistry, quantum statistical mechanics

Herbert Morawetz, Institute Professor, Professor of Polymer Chemistry
B.A.Sc., M.S.Sc., University of Toronto; Ph.D., Polytechnic Institute of Brooklyn
Polymer reactions, hindered rotation in polymer systems, properties of polymer gels, polymer compatibility

Shirley M. Motzkin, Professor of Biology
B.S., Brooklyn College; A.M., Columbia University; Ph.D., New York University
Development mechanisms, teratology and skeletal development, radiation effects

Ronald Parks, Professor of Physics and Chemistry and Head, Department of Physics
B.S., Kansas State University; M.S., Ph.D., Stanford University
Surface physics and chemistry
William T. Winter, Associate Professor of Polymer Chemistry
B.S., Ph.D., SUNY (College of Environmental Science & Forestry), Syracuse University
Polymer morphology and crystallography
polysaccharides and other biopolymers

Mary K. Cowman, Assistant Professor of Biochemistry
B.S., M.S., Ohio University, Ph.D., Case Western Reserve
Interactions of extracellular matrix components

Subhash C. Narang, Assistant Professor of Organic Chemistry
B.Sc., M.Sc., Punjab University, Ph.D., Flinders University
New synthetic methods and reagents, reaction mechanisms, polymeric reagents, photoresists, photoelectro organic chemistry

Matthew Schlecht, Assistant Professor of Organic Chemistry
B.S., University of Wisconsin, M.A., Ph.D., Columbia University
Synthetic methods, synthesis of natural products

Donald M. Schleich, Assistant Professor of Inorganic Chemistry
B.S., SUNY (Fredonia); Ph.D., Brown University
Photoelectrochemistry, intercalation and materials studies

Sybilla Kennedy, Academic Associate and Director of Laboratories (Farmingdale)
B.A., Smith College; M.A., SUNY (Stony Brook)

EMERITUS FACULTY

Herman F. Mark, Professor Emeritus of Polymer Chemistry and Dean Emeritus
B.S., Ph.D., University of Vienna
Synthesis, characterization, and properties of natural and synthetic polymers
Civil and Environmental Engineering

Civil engineers are professionals involved in building the structures and infrastructures of modern society. They design and supervise the construction of buildings, bridges, roads, airports, dams, irrigation systems, harbors, wastewater and water supply plants, tunnels and offshore platforms. The wide spectrum of the civil engineering profession is reflected by the technical divisions of the American Society of Civil Engineers—aerospace, air transport, construction, energy, engineering mechanics, environmental engineering, geotechnical engineering, highways, hydraulics, irrigation and drainage, pipeline, structural, surveying and mapping, urban planning and development, urban transportation, water resources planning and management, waterway, port, coastal and ocean engineering.

Many civil engineers, as licensed professionals, are in private practice as consultants to corporations, governmental agencies, architects and others that require their expertise. Others own construction companies and fabrication operations. Civil engineers act as city and regional engineers, interacting with planning officials, political authorities and the public to develop and maintain the nation's vital transportation links, public services and shelter.

Environmental engineering is closely linked to civil engineering but goes beyond the "design and build" function to examine problems of scarce natural resources, pollution and waste disposal. Environmental scientists do not practice as licensed professionals but perform vital functions in quality monitoring, environmental impact studies and research and development.

Many civil engineers continue beyond the bachelor's degree to advanced studies and research at the master's, engineer's and doctoral levels. Others branch out into advanced studies in management, planning and medicine.

The undergraduate program is accredited by the Accreditation Board for Engineering and Technology.

Undergraduate Program

The fundamental sciences of mathematics, physics and chemistry are presented first, together with additional subjects such as English, history, language and economics designed to broaden the student's intellectual horizons. The program then introduces the basic engineering sciences, including properties of materials, fluids, soils, electricity, thermodynamics and stress analysis. In the last phase of the program, professional applications—such as highways, environmental engineering and detailed design of structures—are studied. The emphasis is on preparing students broadly in all of the major areas of civil and environmental engineering so that the graduates can be immediately employed in the profession.

Electives

In order to allow the students to broaden their knowledge, elective subjects are provided. Senior courses in other departments may be selected as well as some courses in the graduate program. Approved technical electives are indicated below; other courses may be chosen with the approval of the department adviser.

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical Electives</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 272</td>
<td>Construction Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 315</td>
<td>Soils Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 335</td>
<td>Advanced Structural Design</td>
<td>3</td>
</tr>
<tr>
<td>CE 336</td>
<td>Timber and Masonry Structures</td>
<td>3</td>
</tr>
<tr>
<td>CE 345</td>
<td>Hydraulic Engineering</td>
<td>3</td>
</tr>
<tr>
<td>IE 300</td>
<td>Engineering Economic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MA 153</td>
<td>Elements of Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MA 217</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>MA 223</td>
<td>Introduction to Probability</td>
<td>3</td>
</tr>
<tr>
<td>MA 260</td>
<td>Vector Analysis and Partial</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Differential Equations</td>
<td></td>
</tr>
<tr>
<td>PH 240</td>
<td>Optics</td>
<td>3</td>
</tr>
<tr>
<td>TR 360</td>
<td>Traffic Planning and Operations</td>
<td>3</td>
</tr>
<tr>
<td>TR 361</td>
<td>Transportation Models</td>
<td>3</td>
</tr>
<tr>
<td>TR 362</td>
<td>Public Transportation Technology and Operations</td>
<td>3</td>
</tr>
</tbody>
</table>

ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101–104 (physical education); juniors and seniors may substitute three of the following two-credit courses: MS 301, 303, 401, 403 for six credits of technical electives.
EVENING SESSION

Most civil engineering courses in the undergraduate listing will be offered only on an alternate-year basis. Exceptions to this plan are courses CE 150, CE 202, CE 303, CE 222, CE 322, CE 391, CE 392, which will be offered each year. Students enrolled in the evening session should contact the evening adviser or departmental office for details about this plan. A suggested eight-year evening program leading to the B.S. in civil engineering degree is given on the following page.

Typical Course of Study for the Bachelor of Science Degree in Civil Engineering

Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2½</td>
<td>0</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab I</td>
<td>0</td>
<td>1½</td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>HU 101</td>
<td>College Composition</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AM 101</td>
<td>Graphics</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Summer camp (2-week session)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CE 150</td>
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</table>

Sophomore Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 103</td>
<td>Calculus III</td>
<td>3</td>
</tr>
<tr>
<td>PH 103</td>
<td>Introductory Physics III</td>
<td>2½</td>
</tr>
<tr>
<td>AM 116</td>
<td>Engineering Mechanics I</td>
<td>2</td>
</tr>
<tr>
<td>CE 151</td>
<td>Surveying</td>
<td>3</td>
</tr>
<tr>
<td>HU 200</td>
<td>Introduction to Literature</td>
<td>3</td>
</tr>
<tr>
<td>PE 103</td>
<td>Physical Education</td>
<td>0</td>
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Junior Year

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<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td>CE 222</td>
<td>Fluid Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>CE 322</td>
<td>Theory of Structural I</td>
<td>3</td>
</tr>
<tr>
<td>CE 351*</td>
<td>Highway &amp; Transp. Eng.</td>
<td>2</td>
</tr>
<tr>
<td>AM 201</td>
<td>Thermodynamics I</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics elective</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
<td>0</td>
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Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>CE 252</td>
<td>Reinforced Concrete Struct.</td>
<td>3</td>
</tr>
<tr>
<td>CE 317</td>
<td>Foundations</td>
<td>2</td>
</tr>
<tr>
<td>CE 341</td>
<td>Environmental Engineering I</td>
<td>2</td>
</tr>
<tr>
<td>Mathematics elective</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Hum./Soc. Sci. elective</td>
<td>6</td>
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</tr>
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Minimum total credits required for graduation: 136

* Offered in the second semester at Farmingdale
** Offered in the first semester at Farmingdale
# Suggested Eight-Year Program Leading to the Bachelor of Science Degree in Civil Engineering

<table>
<thead>
<tr>
<th>First Year</th>
<th>Hours/Week</th>
<th>Second Year</th>
<th>Hours/Week</th>
</tr>
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<tbody>
<tr>
<td><strong>First Semester</strong></td>
<td></td>
<td><strong>Second Semester</strong></td>
<td></td>
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<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
</tr>
<tr>
<td>HU 101 College Composition</td>
<td>3 0 3</td>
<td>PH 101 Introductory Physics I</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SS 104 Contemporary World History</td>
<td>3 0 3</td>
</tr>
<tr>
<td><strong>Second Year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MA 103 Calculus III</td>
<td>3 0 3</td>
<td>MA 104 Applied Differential Equations</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH 102 Introductory Physics II</td>
<td>3½ 1½ 4</td>
<td>PH 103 Introductory Physics III</td>
<td>2½ 1½ 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CS 100 Int. to Programming</td>
<td>2 0 2</td>
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<tr>
<td><strong>Third Year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AM 116 Engineering Mechanics I</td>
<td>2 0 2</td>
<td>AM 117 Engineering Mechanics II</td>
<td>2 0 2</td>
</tr>
<tr>
<td>CM 101 General Chemistry I</td>
<td>2½ 0 2½</td>
<td>CM 102 General Chemistry II</td>
<td>2½ 0 2½</td>
</tr>
<tr>
<td>CM 111 General Chemistry Lab. I</td>
<td>0 1½ ½</td>
<td>CM 112 General Chemistry Lab. II</td>
<td>0 1½ ½</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CS 100 Int. to Programming</td>
<td>2 0 2</td>
</tr>
<tr>
<td><strong>Fourth Year</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CE 202 Mechanics of Materials</td>
<td>3 0 3</td>
<td>CE 322 Theory of Structures I</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CE 303 Nature &amp; Prop. of Struc. Mtls.</td>
<td>1 3 2</td>
<td>CE 222 Fluid Mechanics</td>
<td>3 3 4</td>
</tr>
<tr>
<td>EE 370 Principles of E E</td>
<td>3 0 3</td>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
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<td>10</td>
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<tr>
<td><strong>Fifth Year</strong></td>
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<td></td>
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<tr>
<td>CE 323 Theory of Structures II</td>
<td>3 0 3</td>
<td>CE 252 Reinforced Concrete Structures</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CE 331 Steel Structures</td>
<td>3 0 3</td>
<td>CE 151 Surveying</td>
<td>3 3 4</td>
</tr>
<tr>
<td>CE 232 Soil Mechanics</td>
<td>2 3 3</td>
<td>CE 317 Foundations</td>
<td>2 3 3</td>
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<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td><strong>Sixth Year</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>CE 340 Water Resources &amp; Hydr. Eng.</td>
<td>3 0 3</td>
<td>CE 341 Environmental Engineering I</td>
<td>2 3 3</td>
</tr>
<tr>
<td>CE 214 Computer Techniques in Eng.</td>
<td>3 0 3</td>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
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<tr>
<td>Hum./Soc. Sci. elective</td>
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<tr>
<td><strong>Seventh Year</strong></td>
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<tr>
<td>CE 332 Design of Structural Systems</td>
<td>2 3 3</td>
<td>CE 351 Highway &amp; Transportation Eng</td>
<td>2 3 3</td>
</tr>
<tr>
<td>AM 201 Thermodynamics I</td>
<td>3 0 3</td>
<td>Technical elective</td>
<td>3 0 3</td>
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<tr>
<td>Technical elective</td>
<td>3 0 3</td>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
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<td></td>
<td>9</td>
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<tr>
<td><strong>Eighth Year</strong></td>
<td></td>
<td></td>
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<tr>
<td>CE 342 Environmental Engineering II</td>
<td>2 3 3</td>
<td>Technical elective</td>
<td>3 0 3</td>
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<tr>
<td>CE 305 Eng. Contracts &amp; Specifications</td>
<td>2 0 2</td>
<td>Hum./Soc. Sci elective</td>
<td>3 0 3</td>
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<tr>
<td>Technical elective</td>
<td>3 0 3</td>
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<td>6</td>
</tr>
<tr>
<td>Minimum total credits required for graduation: 136</td>
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</table>

*This 2-week course will be offered every May during the day.*

*Offered in alternate even years, i.e., 1984-1985, 1986-1987.*

*Normal credit completion by end of third year = 52 credits*

*Offered in alternate odd years, i.e., 1983-1984, 1985-1986.*

*The fifth and sixth years are interchangeable.*

*The seventh and eighth years are interchangeable.*
GRADUATE STUDY

Programs of study are offered leading to the degrees of master of science in civil engineering, master of science in environmental health science, engineer in civil engineering and doctor of philosophy in civil engineering.

The requirements for the master's degree include prescribed courses and approved elective courses. A thesis or a project may be substituted for elective courses. A minimum of 36 units is required for the degree.

The engineer degree is oriented toward civil engineers who wish to study advanced engineering techniques beyond the master's degree. A minimum of 24 units of approved graduate courses and a minimum of 12 units of design project are required.

The Ph.D. degree requires advanced study beyond the master's degree level in the field of civil engineering. A thesis characterized by originality must be written and defended.

REQUIREMENTS FOR THE MASTER'S DEGREE

A bachelor's degree in civil engineering is required for students pursuing a master's degree in civil engineering. Those seeking the master's degree in environmental health science are required to hold a bachelor's degree in science. Applicants with degrees in other fields may be admitted with undergraduate deficiencies as evaluated by the departmental graduate adviser. Typical programs are illustrated subsequently.

Courses in some areas of specialization are not offered on a regular basis. The student should consult with the department head to determine the expected scheduling of such courses.

AREAS OF SPECIALIZATION

Structural Engineering Program

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 601</td>
<td>Theory of Structural Analysis and Design I</td>
<td>3</td>
</tr>
<tr>
<td>CE 602</td>
<td>Theory of Structural Analysis and Design II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Minimum of nine units from the courses listed immediately below.</td>
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<tr>
<td>CE 609</td>
<td>Matrix Methods of Structural Analysis I</td>
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</tr>
<tr>
<td>CE 611</td>
<td>Limit Design of Metal and Concrete Structures I</td>
<td>9</td>
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<tr>
<td>CE 614</td>
<td>Metal Structures I</td>
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<tr>
<td>CE 641</td>
<td>Reinforced Concrete Structures I</td>
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Water Resources and Hydraulic Engineering Program

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
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<tbody>
<tr>
<td>CE 715</td>
<td>Open Channel Hydraulics</td>
<td>3</td>
</tr>
<tr>
<td>CE 716</td>
<td>Hydraulic Problems</td>
<td>3</td>
</tr>
<tr>
<td>CE 722</td>
<td>Hydrology I</td>
<td>3</td>
</tr>
<tr>
<td>CE 724</td>
<td>Water Resources Planning</td>
<td>3</td>
</tr>
<tr>
<td>CE 723</td>
<td>Hydrology II</td>
<td>3</td>
</tr>
<tr>
<td>CE 732</td>
<td>Coastal Engineering</td>
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Environmental Engineering and Planning Program

<table>
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<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>CE 738</td>
<td>Sanitary Chemistry</td>
<td>3</td>
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<tr>
<td>CE 740</td>
<td>Sanitary Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>CE 742</td>
<td>Water and Wastewater Treatment I</td>
<td>3</td>
</tr>
<tr>
<td>CE 743</td>
<td>Water and Wastewater Treatment II</td>
<td>3</td>
</tr>
<tr>
<td>CE 747</td>
<td>Analysis of Stream and Estuary Pollution</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Required units</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Minimum elective units</td>
<td>21</td>
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<td>Minimum total units</td>
<td>36</td>
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Environmental Health Science

<table>
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<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
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<tr>
<td>CE 751</td>
<td>Environmental Health Engineering</td>
<td>3</td>
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<tr>
<td>CE 759</td>
<td>Engineering Aspects of Regional and Master Planning</td>
<td>3</td>
</tr>
<tr>
<td>CE 760</td>
<td>Planning and Engineering of Urban Environmental Systems I</td>
<td>3</td>
</tr>
<tr>
<td>CE 761</td>
<td>Planning and Engineering of Urban Environmental Systems II</td>
<td>3</td>
</tr>
<tr>
<td>CE 762</td>
<td>Urban Environmental Systems Workshop</td>
<td>3</td>
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<tr>
<td></td>
<td>Required units</td>
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<tr>
<td></td>
<td>Minimum elective units</td>
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<td>Minimum total units</td>
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Environmental Planning

<table>
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<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 751</td>
<td>Environmental Health Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 759</td>
<td>Engineering Aspects of Regional and Master Planning</td>
<td>3</td>
</tr>
<tr>
<td>CE 760</td>
<td>Planning and Engineering of Urban Environmental Systems I</td>
<td>3</td>
</tr>
<tr>
<td>CE 761</td>
<td>Planning and Engineering of Urban Environmental Systems II</td>
<td>3</td>
</tr>
<tr>
<td>CE 762</td>
<td>Urban Environmental Systems Workshop</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Required units</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Minimum elective units</td>
<td>21</td>
</tr>
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<td></td>
<td>Minimum total units</td>
<td>36</td>
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Highway Engineering Program

<table>
<thead>
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<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
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<tbody>
<tr>
<td>CE 801</td>
<td>Flexible Pavements—Design and Evaluation</td>
<td>3</td>
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<tr>
<td>CE 802</td>
<td>Rigid Pavements—Design and Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>CE 805</td>
<td>Traffic Studies</td>
<td>3</td>
</tr>
<tr>
<td>CE 821</td>
<td>Design of Traffic Facilities and other</td>
<td></td>
</tr>
<tr>
<td>CE 759</td>
<td>Engineering Aspects of Regional and Master Planning</td>
<td></td>
</tr>
<tr>
<td>CE 812</td>
<td>Transportation Economics Required units</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Minimum elective units</td>
<td>21</td>
</tr>
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<td>Minimum total units</td>
<td>36</td>
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Geotechnical Engineering Program

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>CE 881</td>
<td>Special Topics in Soil Mechanics and Foundation Engineering I or II</td>
<td>3</td>
</tr>
<tr>
<td>CE 882</td>
<td>Special Topics in Soil Mechanics and Foundation Engineering II</td>
<td></td>
</tr>
<tr>
<td>CE 861</td>
<td>Soil Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>CE 862</td>
<td>Soil Mechanics II</td>
<td>3</td>
</tr>
<tr>
<td>CE 863</td>
<td>Experimental Soil Mechanics</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Required units</td>
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<tr>
<td></td>
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<td>24</td>
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<td>Minimum total units</td>
<td>36</td>
</tr>
</tbody>
</table>

REQUIREMENTS FOR THE ENGINEER DEGREE

A master's degree in civil engineering meeting the specialization area requirements for the Polytechnic master's degree is generally required for admission. Applicants with master's degrees in other engineering disciplines may be admitted with deficiencies as evaluated by the departmental adviser. A minimum of 36 units of work beyond the master's degree is required, of which at least 27 units must be completed at Polytechnic. This work must include a 12-unit design project. The engineer degree may be earned in any area of specialization except environmental health science. The program for this degree follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 998</td>
<td>Project for the Degree of Engineer</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>An approved elective in applied mathematics, or operations research</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Nine units of courses in areas of specialization selected with the consent of the adviser</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Required units</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Minimum elective units</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Minimum total units</td>
<td>36</td>
</tr>
</tbody>
</table>

REQUIREMENTS FOR THE DOCTOR'S DEGREE

Students pursuing the doctorate in civil engineering must hold a master's degree in civil engineering. For the doctorate in environmental health science, a master's degree in science is a prerequisite. Applicants with degrees in other fields may be admitted with deficiencies as evaluated by the departmental graduate adviser.

Each candidate for the doctorate must complete a minimum of 66 units of academic work beyond the master's degree, of which at least 57 units must be completed at Polytechnic. In any case, the candidate must complete not less than 90 units of work past the bachelor's degree. Of the units taken at Polytechnic, at least 27 must be formal course work (not including guided readings, seminar, or project). Registration for a minimum of 30 units of dissertation research is required at the rate of a minimum of six units per term, continuously, until the dissertation has been completed and accepted.

Students interested in the Ph.D. program are advised to refer to the Civil Engineering Graduate Study Guide (available from the department head) for information on qualifying examinations and other regulations.

UNDERGRADUATE COURSES

CE 150 Surveying Fieldwork 2 credits
Field exercises involving the rudiments of elementary surveying, route surveying and geodetic surveying given at summer camp (two weeks). Prerequisite: MA 101.

CE 151 Surveying 3:3:4
Modern methods and computations for engineering surveys. Fundamental theory of photogrammetry with laboratory exercises. Prerequisites: CE 150 and AM 101.

CE 202 Mechanics of Materials 3:3:3
Basic principles of stress and strains of members subjected to direct force, tension and bending. Deformations of beams. Statically determinate and indeterminate problems. Column stability. Prerequisite: AM 115 or AM 116. Also listed under AM 121.

CE 214 Computer Techniques in Engineering 3:3:3
Course devoted to use of higher-level computer languages and techniques in engineering. Use of digital computer for numerical methods involving differentiation, integration and solution of systems of equations. Problem-oriented languages in engineering design practice. Computer graphics in engineering. Prerequisites: CS 100 and MA 104.

CE 222 Fluid Mechanics 3:3:3
Fluid-flow concepts including continuity, energy and momentum equations, laminar and turbulent flow, boundary-layer drag, dimensional analysis, Euler's equations and two-dimensional ideal fluid flow. Hydrostatics. Pipe flow, pumps, turbines, fluid measurements. Prerequisites: AM 115 or AM 116 and AM 117.
CE 232 Soil Mechanics  2:3:3

CE 252 Reinforced Concrete Structures  3:0:3
Fundamentals of analysis and design of reinforced concrete beams, columns, slabs. Prerequisite: CE 322.

CE 272 Construction Engineering  3:0:3
Construction methods and management. Planning of construction operations, including cost estimating, bid preparation, time scheduling and economic evaluation of alternatives. Project planning and resource allocation utilizing the critical path method and PERT. Prerequisite: senior status.

CE 303 Nature and Properties of Structural Materials  1:3:2

Also listed under MT 303

CE 305 Engineering Contracts and Specifications  2:0:2
Detailed analysis of engineer's part in preparation of engineering contracts and specifications. Prerequisite: CE 202.

CE 315 Soils Engineering  3:0:3

CE 317 Foundations  2:3:3
Site exploration and soil sampling; planning boring programs and interpretation of boring logs. Bearing capacity of footings and mats for granular soils and clays. Settlements of structures. Lateral earth pressures and proportions of retaining walls. Pile foundations. Prerequisite: CE 232 and Co/Prerequisite: CE 252.

CE 322 Theory of Structures I  3:0:3

CE 323 Theory of Structures II  3:0:3

CE 331 Steel Structures  3:0:3
Design of steel beams and girders, tension members, columns. Bolted, riveted and welded connections. Prerequisite: CE 322.

CE 332 Design of Structural Systems  2:3:3

CE 335 Advanced Structural Design  3:0:3

CE 336 Timber and Masonry Structures  3:0:3

CE 340 Water Resources and Hydraulic Engineering  3:0:3

CE 341 Environmental Engineering I  2:3:3

CE 342 Environmental Engineering II  2:3:3
Integrated lecture and design periods covering water distribution systems, water filtration units and principal components of wastewater treatment plant for a small community. Introduction to air quality and solid waste problems. Prerequisites: CE 341 and CE 340.

CE 345 Hydraulic Engineering  3:0:3

CE 351 Highway and Transportation Engineering  2:3:3
Fundamentals of highway and transportation engineering including land, urban, air and water transportation. Geometric design, capacity intersection design, drainage, economic analysis and finance, rigid and flexible pavements, velocity profile and performance, evaluation, future developments. Prerequisite: CE 151.

CE 391-392 Bachelor’s Thesis in Civil Engineering each 2 credits
Original research, design or plan for approved engineering project. Thesis gives students opportunity to apply knowledge and training gained in course of study by approaching and successfully solving a comprehensive problem. Conferences held regularly with appointed members of staff. Thesis registration required each semester. Students must reregister for thesis until completed. Prerequisite: senior status.

CE 396 Civil Engineering Internship  2:0:2
A supervised, creative civil engineering experience of at least two months' performance judged on the basis of written and oral reports presented to the industrial and faculty supervisors. Regular faculty visitations and conferences arranged during the internship. Open to students who have completed their
junior year and have departmental approval prior to beginning the internship experience. Prerequisite: department's permission.

**CE 398 Project in Civil Engineering** 2 or 3 credits as arranged

Solution to civil engineering problem or detailed study of advanced area of civil engineering under close supervision of adviser. Prior to undertaking the project, interested students must submit to course director detailed written proposals of the problem they intend to investigate, along with number of credits for which they decide to register. Results of project must be submitted to the department as a formal report.

**GRADUATE COURSES**

**STRUCTURAL ENGINEERING**

**Prerequisites for all courses:** MA 104, CE 323

**CE 601 Theory of Structural Analysis and Design I** 2%:0:3

Theories of structural action, including elastic and plastic behavior and their relationship to design. Classical structural mechanics, matrix procedures and numerical methods of analysis as well as their interrelationships. Influence lines, elastic supports, settlement and rotation of supports. Applications to statically indeterminate frames and trusses. Prerequisites: CE 252 and CE 331.

**CE 602 Theory of Structural Analysis and Design II** 2%:0:3

Analysis of arches, rings and continuous arches on slender piers. Frames and continuous curved members subjected to lateral and out-of-plane loading. Space frameworks, secondary and participation stresses, buckling of frames, trusses, arches. Prerequisite: CE 601.

**CE 603-604 Special Topics in Structural Analysis I, II** 2%:0:3

Specialized current topics of interest offered at irregular intervals by advance announcement. Graduate adviser may approve repeated registration for different topics. Prerequisite: CE 601.

**CE 605 Plate and Shell Structures** 2%:0:3


**CE 609 Matrix Method of Structural Analysis I** 2%:0:3


**CE 610 Matrix Method of Structural Analysis II** 2%:0:3

Extension of matrix methods to grid frames, curved members, space structures, nonlinear analysis and optimization of structures. Prerequisite: CE 609.

**CE 611 Limit Design of Metal and Concrete Structures I** 2%:0:3

Application of plastic theory of structural behavior to design of civil engineering structures. Particular emphasis on steel and reinforced concrete beams and frames. Co/Prerequisite: CE 601.

**CE 612 Limit Design of Metal and Concrete Structures II** 2%:0:3


**CE 613 Stability of Structures** 2%:0:3

Critical loads of elastic members and frameworks from characteristic-value problem formulations, considering lateral and torsional displacements. Stability of inelastic members, including initially strained steel shapes. Solutions by numerical methods. Behavior of members and frames with initial geometrical imperfections and transverse loading. Ultimate load of plate girders. Prerequisite: CE 602.

**CE 614 Metal Structures I** 2%:0:3

Current developments in design of metal structures, including design of light-gauge, cold-formed members, orthotropic bridge decks and structural applications of aluminum. Co/Prerequisite: CE 601.

**CE 615 Metal Structures II** 2%:0:3

Techniques for designing cable-suspended and cable-stayed structures, lattice shells, space frameworks and other complex structures. Application of nonlinear analysis utilizing electronic digital computers. Prerequisite: CE 614.

**CE 616 Finite Element Analysis of Structural Systems** 2%:0:3


**CE 621 Advanced Mechanics of Materials** 2%:0:3

Unsymmetrical bending of elastic bars, shear center for members of thin-walled open cross section, curved beams, beams on elastic foundations, membrane and bending stresses in shells, shells. Also listed under AM 611

**CE 622 Experimental Mechanics** 1%:2:0

Application of experimental stress analysis techniques to aerospace, civil and mechanical engineering structures. Mechanical strain gauges, Bagg's deformers, the use of electrical strain gauges and associated instrumentation, bristle coating, photelasticity and photostrast Measurements. Static and dynamic loading, creep and fatigue of structural elements. Also listed under AM 625

**CE 623 Numerical Methods in Civil Engineering** 2%:0:3

Formulation of numerical techniques for solution of various problems in civil engineering. Topics include finite difference, numerical integration and relaxation methods. Critical path method in construction management. Elements of linear programming.

**CE 625 Structural Dynamics** 2%:0:3


Also listed under AM 661.
CE 627 Dynamic Response of Civil Engineering Structures* 2/3:0:3
Description of dynamic loading on civil engineering systems. Effect of wind on bridges, suspension systems and tall buildings using random vibration theory. Earthquake analysis of structures responding elastically. Application to problems in material behavior such as fatigue in cables, hysteretic loops in concrete and steel and damping in structural systems. Prerequisite: CE 625.

CE 632 Introduction to Piping Analysis 2/3:0:3
Use of displacement energy, complementary energy and thermeelastic reciprocal theorem in solution of problems of plane bending of rings, frames and piping; three-dimensional analysis of piping systems; computational methods of analysis using concepts of elastic center, bending of bimetallic and layered elements. Prerequisites: AM 601-602 or equivalent. Also listed under AM 632

CE 641 Reinforced Concrete Structures I 2/3:0:3
Elastic and ultimate strength design of reinforced concrete members. Shear and torsion effects on beams. Analysis and design of prestressed concrete structures. Prerequisite: CE 252 and Co/Prerequisite: CE 601.

CE 642 Reinforced Concrete Structures II 2/3:0:3
Biaxial bending of columns. Stability of reinforced concrete columns. Designs of two-way and flat slabs, arches and horizontally curved members. Shear wall design and design problems of tall structures. Prerequisite: CE 641 and Co/Prerequisite: CE 602.

WATER RESOURCES AND HYDRAULIC ENGINEERING

Prerequisite for all courses: MA 104, CE 222, except as indicated

CE 711 Hydraulic Design of Structures 2/3:0:3
Hydraulic principles utilized in design of structures such as spillways, measuring flumes, energy dissipators, channels of linear and nonlinear alignment, gradual and sudden transition in subcritical and supercritical flow, culverts, lateral spillway channels. Co/Prerequisite: CE 715

CE 715 Open Channel Hydraulics 2/3:0:3
Theory and computations for uniform flow, gradually varied flow, rapidly varied flow, unsteady flow in prismatic and non-prismatic channels.

CE 716 Hydraulic Problems*. 2/3:0:3
Similarly, dimensional analysis and modeling techniques as applied to hydraulic systems. Pumping systems including hydraulic transients and flow of air, liquids, sludge. Sediment transport. Cavitation. Co/Prerequisite: CE 715

CE 717 Hydraulics for Civil Engineers* 2/3:0:3
Application of basic concepts of fluid mechanics and hydraulic principles in turbulent flow, stratified flow and other problems of special interest to civil engineers.

CE 722 Hydrology I 2/3:0:3
Hydrologic cycle. Meteorological considerations. Analyses of precipitation, runoff, unit hydrograph, flood routing and reservoir storage. Principles of groundwater hydrology. Introduction to frequency analyses of floods and droughts. Prerequisite: undergraduate degree in engineering or science.

CE 723 Hydrology II 2/3:0:3
Studies of duration curves, reservoir operation, urban drainage, temperature and snowmelt, erosion, sedimentation, statistical methods in hydrology, including analysis of floods and droughts and other hydrologic events; streamflow simulation.

CE 724 Water Resources Planning 2/3:0:3
Water resources investigations, comparison of alternatives, screening and formulation of projects, economic analysis of single and multipurpose projects. Financial management, legal and other considerations. Applications of system analysis. Prerequisite: undergraduate degree in engineering or science.

CE 725 Water Resources Mathematical Modeling* 2/3:0:3
The study of hydraulic, hydrologic, water quality and systems models as applied to rivers and streams, embankments, reservoirs and basins. Review of basic equations of flow applicable to these models. Appropriate modeling techniques using computer-based solutions reviewed with emphasis on time-varying boundary conditions and problems of calibration and verification. One-, two- and three-dimensional models considered. Stormwater models and water resource systems modeling also covered. Prerequisite: course in computer programming and Co/Prerequisite: CE 715

CE 732 Coastal Engineering* 2/3:0:3
Basic concepts of wind-wave induced phenomena in near shore areas as associated with problems of shoreline protection. Wave-water dynamics as applied to coastal structures, including effect of hurricanes on maximum storm tides, wave heights, pressures.

CE 733 Forces on Marine Structures* 2/3:0:3
Analysis of forces on marine structures such as piers, platforms, jetties, subjected to hydrodynamic and other loads. Waves as random processes: Application of wave forecasting and spectra. Description of interaction between wave forces and structural response.

CE 734 Design of Marine Structures* 2/3:0:3
Planning of port facilities and coastal protection. Problems involved in design of marine structures. Choice of design parameters as affected by hydrodynamic and other loads.

CE 735-736 Special Topics in Water Resources and Hydraulic Engineering I, II* 2/3:0:3
Topics of special interest in water resources and hydraulic engineering. Such topics may include hydroeconomic models, finite difference and finite element models, synthetic hydrology; conjunctive use of surface water, groundwater, desalinated and recycled water; thermohydrologic and hydrometeorological problems; flushing of estuaries; hydromechanics of oil pollution, sludge dumping, and sediment movement; environmental design of hydraulic structures; problems of macro projects. Prerequisite: permission of instructor.

ENVIRONMENTAL ENGINEERING

CE 738 Sanitary Chemistry 1:2:3
Lectures and laboratory work. Review and application of principles of chemistry to waters and wastewaters. Laboratory analyses of representative waters and wastewaters for most commonly determined parameters as related to applications in water environment. Evaluation of methods and procedures used.

CE 739 Chemistry for Sanitary Engineers* 2/3:0:3
The study of physical chemistry, organic chemistry, biochemistry involved in water and wastewater treatment. Course provides advanced study of principles illustrated in CE 738. Prerequisite: CE 738.
CE 740 Sanitary Microbiology 2:1:3
Lectures and laboratory work. Microbiology of wastewater treatment processes, wastewaters, receiving waters. Includes microorganisms and ecological relationships. Laboratory includes identification and microbiological examination of waters and wastewaters.

CE 741 Analysis of Water Quality Systems* 2½:0:3
Fundamental study of chemistry, biochemistry, microbiology and application of these principles to water and wastewater treatment. Study of natural water-courses in relation to natural and man-made pollution. Techniques of evaluating self-purification capacity of streams, lakes, estuaries.

CE 742 Water and Wastewater Treatment I 2½:0:3
Study of physical, chemical and biological principles involved in process design and treatment of water and wastewater. Topics include sedimentation, filtration, softening, chemical treatment, coagulation, flocculation, desalination, taste and odor control. Co/Prerequisite: CE 738.

CE 743 Water and Wastewater Treatment II 2½:0:3
Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. Prerequisite: CE 740.

CE 744 Unit Operation in Water and Wastewater Treatment* 2½:0:3
Advanced study of various biological, physical and chemical principles involved in water and wastewater treatment. A rational approach and theoretical development of design relationships commonly used in the design of unit processes. Prerequisites: CE 742 and CE 743.

CE 745 Water and Wastewater Treatment Laboratory* 1:2:3
Laboratory process course in water and wastewater engineering dealing with physical, chemical and biological methods and principles. Processes include disinfection, softening, sedimentation, oxygen transfer, coagulation, adsorption, filtration, aerobic and anaerobic biological treatment systems, Warburg analysis of a waste. Co/Prerequisite: CE 743.

CE 746 Industrial Waste Treatment 2½:0:3

CE 747 Analysis of Stream and Estuary Pollution 2½:0:3
Analysis of dispersal and decay of contaminants introduced into lakes, streams, estuaries, oceans. Effects of pollutants on chemical quality and ecology of receiving waters.

CE 748 Sanitary Engineering Design 1:2:3
Design of water supply and wastewater treatment systems. Topics of special interest. Co/Prerequisite: CE 743.

CE 751 Environmental Health Engineering 2½:0:3
Theory, methodology and instrumentation associated with environmental health. Topics include epidemiology, food vectors, radiation, pest control, heating, ventilation, noise, illumination, hazards of home and community environment, other subjects which affect public health.

CE 752 Air Pollution* 2½:0:3

CE 753 Dispersion of Pollutants* 2½:0:3

CE 755 Air Pollution Chemistry* 2½:0:3
Significant chemical reactions occurring in lower atmosphere and basic chemistry required to understand problems peculiar to air pollution field. Chemistry applicable to fuel combustion and other sources of atmospheric pollution.

CE 756 Air Pollution Analysis* 2½:0:3
Principles of reaction or physical measurement used for variety of analytical equipment employed in air pollution studies. Analysis of various atmospheres and evaluation of results. Prerequisite: CE 755.

CE 757 Air Pollution Effects* 2½:0:3
Effects of atmospheric pollution on various forms of life, including both direct and secondary effects. Corrosion or contamination of inanimate matter by pollutants.

CE 758 Air Pollutant Engineering Control 2½:0:3
Fundamentals of adsorptive, absorptive, and reactive recovery and control, removal of gaseous oxides of nitrogen, carbon and sulfur; removal of particulates from moving and stationary sources; removal of fluorides; complex oxides, and mercury vapors. Taught in the Department of Chemical Engineering.

CE 759 Engineering Aspects of Regional and Master Planning 2½:0:3
Stresses influence and especially constraints imposed on population levels and land use by various engineering systems required to serve the plan region. Current concepts and methodology dealing with conservation of resources and evaluation of environmental impact of engineering systems and techniques for decision-making for selecting engineering alternatives in regional planning. Prerequisite: engineering degree.

CE 760 Planning and Engineering of Urban Environmental Systems I 2½:0:3
Consideration of sociological, political and economic values in planning and engineering of urban communities. Recent techniques for collection, processing and application of demographic, geographic and physical data in design of housing, water supply, solid and liquid waste disposal, other urban environmental subsystems. Zoning regulation and building codes in urban renewal. Prerequisites: B.S. in C.E. (or other engineering degree and equivalent experience).

CE 761 Planning and Engineering of Urban Environmental Systems II* 2½:0:3
Continuation of CE 760. Technology associated with production of housing through conventional and industrialized operations. Influence of building codes, techniques for assessment of quantity and condition of housing stock in urban communities, costs and financial systems for delivery. New town design and renewal of urban communities in context of residential housing and supportive service system. Assessment of energy needs and delivery systems for urban communities. Prerequisite: engineering degree.

CE 762 Urban Environmental Systems Workshop* 2½:0:3
Application of principles, methodology and techniques de-
veloped in CE 760 to planning and engineering of urban communities. These approaches to comprehensive planning of an urban community including housing, water supply, waste disposal, and consideration of physical needs and other implications of service systems such as police, fire protection, hospitals. Co/Prerequisite: CE 760.

CE 763 Aerodynamics of the Urban Environment I* 2½:0:3 Aerodynamic forces and pressures on nonaeronautical shapes—vehicles, buildings, other structures. Unsteady forces and dynamic interactions with structures. Motion and thermal characteristics of atmospheric boundary layer. Air flow and thermal characteristics over urban regions and various topographical configurations. Also listed under AM 751.

CE 764 Aerodynamics of the Urban Environment II* 2½:0:3 Travel and dispersion of atmospheric pollutants. Plume rise and dispersion theories with applications to uniform and nonuniform atmospheres. Effects of boundary configurations of various scales—buildings, urban regions, bodies of water, mountains, valleys. Multiple source urban dispersion. Scale model experimentation. Also listed under AM 752.

CE 766 Industrial Environmental Health Engineering* 2½:0:3 Pertains to field of industrial hygiene, occupational health and workplace safety. Study of causes and effects leading to stressors that may cause sickness, impaired health, and well-being, or discomfort among workers and, indirectly, affect community health. Discussion includes consideration of chemical, biological, ergonomic and physical stressors. Engineering controls designed to alleviate or eliminate such stressors, and the organizations and administrative regulations pertaining to federal, state and local control of the environmental hazards found within industrial establishments. Prerequisite: CE 751.

CE 767 Environmental Impact Evaluation 2½:0:3 An examination of legal and technical requirements in the preparation of environmental impacts. Considerations include legal and technical requirements, the procedure and the interdisciplinary nature of the analysis. Topics include overall impact evaluation, problem definition, quantification of impact, methods used in the analysis, field evaluations, mitigations, hearing procedures and management. Practical examples and case studies used.

CE 770 Solid Waste Management 2½:0:3 Engineering aspects of solid waste collection, transport and disposal, including incineration, sanitary landfill, composting, recovery and reutilization, economic evaluation of factors affecting selection of disposal methods.

CE 771-772 Special Topics in Environmental Engineering I*, II* 2½:0:3 Current topics include: nitrication in natural and treated waters, organic removal from water supplies, water reuse, specialized aspects of biological wastewater treatment, environmental health, solids disposal, and modeling natural waters and treatment systems. Prerequisite: permission of the instructor.

HIGHWAY ENGINEERING

Prerequisites for all courses: MA 101, CE 351

CE 601 Flexible Pavements—Design and Evaluation* 2:1:3 Design and construction of flexible highway pavements including road-mix, plant-mix and high-type bituminous pavements; Pavement performance and evaluation. Laboratory tests of bituminous materials and mixtures, including Marshall, Hubbard-Field and Hveem stability tests. Viscosity by capillary viscosimeter. Also listed under TR 720.


CE 804 Travel Demand Forecasting 2½:0:3 Theory and applications of travel forecasting methods to predict the amount and nature of travel on transportation systems. Emphasis on UMTA Transportation Planning System models. Co/Prerequisite: MA 551 or equivalent. Also listed under TR 601.

CE 805 Traffic Studies 2½:0:3 Techniques for collection of traffic data and information: speed, travel time, volume, origin-destination, parking, accidents, etc. Analysis and interpretation of results. Corrective actions and program formulation based on study results. Prerequisites: MA 551 and TR 701 or equivalents. Also listed under TR 703.

CE 806 Traffic Capacity and Design 2½:0:3 The use of highway capacity analyses techniques in design, planning and operational analysis treated. Highway Capacity Manual methods as well as foreign techniques and recent research developments are discussed and illustrated. Functional design of freeways, arterials, streets and rural highways covered. Also listed under TR 704.

CE 810 Principles of Urban Regional Planning 2½:0:3 A survey of the contemporary theory and methods of the planning function. Also listed under TR 600.

CE 812 Transportation Economics 2½:0:3 A brief review of the principles and concepts of engineering economic analysis and a thorough application of these principles to decision-making in the transportation sector; methods for estimation of capital, operating and direct-user costs in transportation; benefit concepts and estimation of benefits, indirect effects, transportation finance and taxation; concepts of public finance and equity in taxation. Also listed under TR 750.

CE 821 Design of Traffic Facilities 2½:0:3 Presents functional and preliminary design principles and analyses for highways and arterials. Interchange design for freeway facilities and design of at-grade intersections, using principles of channelization. Design of parking garages and parking lots. Also listed under TR 710.

CE 840 Planning and Design of Terminals 2½:0:3 Introductory course in passenger and freight terminals with emphasis on the system description of these facilities. Land, marine and air terminals discussed. Methods discussed for determining the level of service for pedestrian flows, service times for passengers boarding and alighting, transit vehicles and simulation methods for transit terminals. Also listed under TR 670.

CE 841 Airport Planning and Design 2½:0:3 Techniques for forecasting air passenger traffic, aircraft oper-
ations at commercial and general aviation facilities. Principles and practices for the planning and design of terminal facilities, ground transportation systems, parking facilities, runways and navigational aids. Airport site selection, configuration and economics.

Also listed under TR 671

CE 848 Analytical Photogrammetry* 2½:0:3
Detailed presentation of various modern methods for determination of relative and absolute orientation of single photographs and stereo-pairs by analytical methods utilizing data from comparator measurements. Discussion of strip and block adjustments in aerial triangulation.

CE 849 Geodesy* 2½:0:3
Computation of geodetic positions. Properties of earth's figure, theories of astronomic, magnetic and gravity observations, application of least squares to adjustment of surveys. Position determination through satellite observations.

GEOTECHNICAL ENGINEERING

Prerequisites for all courses: MA 104, CE 232, CE 317

CE 851 Earth Pressures and Retaining Structures I 2½:0:3
Couple stress relationships in infinite slopes in granular and cohesive soils. Study of classical works of Rankine, Coulomb, Kersel and others for determining pressure distributions on rigid-type structures retaining soil masses. Effects of ground water seepage, surcharge loading. Shallow and deep sliding failures on retaining structures.

CE 852 Earth Pressures and Retaining Structures II 2½:0:3
Modern earth pressure theories. Evaluation of reality of validity of classical and modern theories. Classical methods for determining pressure distributions on flexible-type retaining structures. Critical evaluation of recent large-scale model tests of sheet-pile bulkheads and their value in supplying design criteria. Treatment of silts, clays, other containers of granular material. Prerequisite: CE 851

CE 881 Soil Mechanics I 2½:0:3
Study of index tests by classical and statistical procedures with emphasis on particle size distribution, particle shape and packing. Stress distribution in homogeneous and layered elastic half-space due to surface loading. Permeability, capillarity, absorption and soil-water tension. Flow networks. Theory of wells and use of well data in field measurement of permeability.

CE 882 Soil Mechanics II 2½:0:3
Classical consolidation theory and recent modifications and extensions; application to problem of settlement of structures. Detailed study of stress-strain-strength relationships in granular and cohesive soils; application to theoretical study of bearing capacity and lateral earth pressure. Stability of slopes and landslide phenomena. Prerequisite: CE 881.

CE 893 Marine Geotechnology* 2½:0:3

CE 897 Energy Policy Issues 2½:0:3
See Energy Program for details.

CE 898 Energy Resource Distribution and Conversion Technology 2½:0:3
See Energy Program for details.

PUBLIC ADMINISTRATION

CE 930 Engineering Projects Related to Public Administration each 3 units
See Polytechnic's Cooperative Program with New York University's Graduate School of Public Administration for details.
CONSTRUCTION MANAGEMENT

CE 825 Construction Administration* 2 1/2:0:3
Management problems unique to construction business including licensing, bonding, insurance, short-term financing, employee relations. Prerequisite: MG 600.
Also listed under MG 825

CE 826 Construction Estimates and Costs* 2 1/2:0:3
Estimates, costs from viewpoint of contractor or construction engineer, details of estimating, emphasis on labor, material, equipment, overhead costs. Prerequisite: CE 825.
Also listed under MG 826

CE 827 Specifications and Contracts* 2 1/2:0:3
Principles of contract law as applied to construction industry, legal problems in preparing and administering construction contracts. Prerequisite: CE 825.
Also listed under MG 827

GUIDED READINGS, SEMINARS, PROJECTS AND THESSES

CE 901 Guided Readings in Civil Engineering 3 units
Individual study of selected literature in civil engineering under guidance of faculty adviser. Acceptable written report or successful completion of examination required. Only one registration permitted. Prerequisite: instructor's approval.

CE 952 Seminar in Civil Engineering
Lectures on recent developments in civil engineering given by representatives from industry, other research and educational institutions, and Polytechnic graduate students and faculty.

CE 996 Project for Master's Degree 3 units
An analytical, design or experimental study in civil engineering under guidance of faculty adviser. Written report required. Project may be expanded into master's thesis with approval of thesis adviser. Prerequisites: degree status and project adviser's approval and department head's approval.

CE 997 Thesis for Degree of Master of Science each 3 units
An original investigation or design in student's principal field of study prepared under close supervision of faculty adviser. Candidate must successfully defend thesis orally. Registration for a minimum total of twelve (12) units required. Maximum of 12 units counted toward degree. Prerequisites: degree status and thesis adviser's approval.

CE 998 Project for Degree of Engineer each 3 units
Comprehensive planning and design of civil engineering project under guidance of faculty adviser. Emphasis on up-to-date techniques. Written report to be submitted on completion of project. Oral examination on project subject must be passed. Registration for minimum total of 12 units required. Maximum of 12 units counted toward degree. Prerequisites: degree status and project adviser's approval.

CE 999 Dissertation for Degree of Doctor of Philosophy each 6 units
Independent original investigation of civil engineering problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized engineering journal. Candidate must successfully defend thesis orally. Registration for minimum of 30 thesis units required prior to defense. Registration must be for minimum of six units per term. Prerequisites: degree status, passing the qualifying examination and thesis adviser's approval.

FACULTY

Carl J. Turkstra, Professor and Head of Civil and Environmental Engineering
B.Sc., Queen's University; M.S., University of Illinois; Dip. Man., McGill University; D.S.A., University of Montreal; Ph.D., University of Waterloo; Professional Engineer.
Structural analysis and design, structural reliability

Paul R. DeCicco, Professor and Director of the Fire Research Center
B.C.E., M.C.E., Polytechnic Institute of Brooklyn; Professional Engineer
Urban systems, fire safety

Alvin S. Goodman, Professor of Civil Engineering
B.C.E., CCNY; M.S.C.E., Columbia University; Ph.D., New York University; Professional Engineer
Water resources

Henry F. Soehngen, Professor of Civil Engineering
B.C.E., M.C.E., Polytechnic Institute of Brooklyn; M.S., International Training Center for Aerial Surveys, Delft (Netherlands); Professional Engineer, Land Surveyor
Computer science, surveying and photogrammetry

Ping Chun Wang, Professor of Civil Engineering
B.S.C.E., National Central University of China; M.S.C.E., Ph.D., University of Illinois; Professional Engineer

Raul R. Cardenas, Jr., Associate Professor of Environmental Engineering
B.A., University of Texas; M.S., Ph.D., New York University
Environmental health science, sanitary engineering

Albert H. Griswold, Associate Professor of Civil Engineering
B.S.C.E., University of Connecticut; M.S.C.E., Columbia University; Professional Engineer
Fluid mechanics

Bernard Grossfield, Associate Professor of Civil Engineering
B.C.E., M.C.E., Eng. Sc.D., New York University; Professional Engineer

Bernard Grossfield, Associate Professor of Civil Engineering
B.C.E., M.C.E., Eng. Sc.D., New York University; Professional Engineer

Alan H. Molof, Associate Professor of Environmental Engineering
B.S., Bucknell University; M.S.E. (Ch.E.), M.S.E. (Sanitary Eng.); Ph.D., University of Michigan
Environmental engineering, water quality

Matthew W. Stewart, Associate Professor of Civil Engineering
B.C.E., M.C.E., Polytechnic Institute of Brooklyn; Professional Engineer
Hydraulic engineering
Ahmed M. Sayed, Assistant Professor of Civil Engineering
B.S., Cairo University; M.S., Ph.D., Polytechnic Institute of New York; Professional Engineer
Structures

Utku Kanlik, Academic Associate
B.S.C.E., M.S.C.E., Middle East Technical University
Water resources engineering

ADJUNCT FACULTY

William T. Ingram, Adjunct Professor of Environmental Engineering
A.B., Stanford University; M.P.H., The Johns Hopkins University

M. Llewellyn Thatcher, Adjunct Associate Professor of Civil Engineering
B.S.E., Princeton University; B.S., Columbia University; S.M., Sc.D., Massachusetts Institute of Technology

Kamal K. Bandyopadhyay, Lecturer
B.C.E., Calcutta University; M.C.E., Ph.D., CCNY

Theodore B. Burger, Lecturer
B.C.E., Manhattan College; M.S. (Sanitary Eng.), Massachusetts Institute of Technology; Ph.D., Polytechnic Institute of New York

Joseph C. Cataldo, Lecturer
B.C.E., M.S.C.E., Ph.D., CCNY

Jeffrey Doynow, Lecturer
B.S.C.E., M.C.E., Rensselaer Polytechnic Institute

Omer A. Fettahlioglu, Lecturer
B.S.C.E., Robert College; M.S.C.E., University of Illinois; Engineer (Aero), Stanford University; Ph.D., Polytechnic Institute of Brooklyn

Clifford Gordon, Lecturer
B.S.C.E., Missouri School of Mines

King Sen Heh, Lecturer
B.S.C.E., M.S.C.E., Polytechnic Institute of New York; E.D., Columbia University

Sufian A. Khondker, Lecturer
B.S.C.E., Bangladesh Engineering University; M.S. Delft University of Technology; Ph.D., Polytechnic Institute of New York

Abdul Q. Mohammad, Lecturer
B.E. (Civil), University of Gauhati; M.S.C.E., University of Missouri; Ph.D., Polytechnic Institute of New York

Anthony V. Rizzl, Lecturer
B.S., CCNY; M.S.C.E., Columbia University

Michael J. Sakala, Lecturer
B.S., Drexel University; M.S.C.E., Polytechnic Institute of New York

Jerome G. Schwartz, Lecturer
B.E., CCNY; M.S., Stevens Institute

Sri K. Sinha, Lecturer
B.S.C.E., Patna University; M.S., CCNY

Joseph W. Vellozzi, Lecturer
B.S., University of Miami; Ph.D., Rensselaer Polytechnic Institute

Karl S. Westermann, Lecturer
B.S.C.E., Polytechnic Institute of Brooklyn

Constantine Yapijakis, Lecturer
M.C.E., National Technical University of Athens; M.S., New York University; Ph.D., Polytechnic Institute of New York

EMERITUS FACULTY

James E. Miller, Professor Emeritus of Meteorology
A.B., Central Methodist College; M.S., New York University
Meteorology and oceanography

Robert C. Veit, Professor Emeritus of Civil Engineering
C.E., Polytechnic Institute of Brooklyn; M.C.E., Polytechnic Institute of Brooklyn
Structures

Chilton A. Wright, Professor Emeritus of Civil Engineering
C.E., M.C.E., Ph.D., Cornell University
Hydraulic engineering
COMPUTER SCIENCE

Computer science is the study of both the theory and the applications of computers. Computer scientists are interested in information processing, simulation and modeling of various systems, and the theoretical foundations of computation. They are concerned with the development of efficient algorithms, of effective languages with which to represent algorithms and of effective means to structure and access information.

The computer science program is administered by the Division of Computer Science of the Department of Electrical Engineering and Computer Science. Its faculty directs the degree programs in computer science and information systems and, in cooperation with the electrical engineering faculty, the degree programs in computer engineering.

UNDERGRADUATE PROGRAMS

The programs in computers are designed to provide the student with broad, basic preparation in the theory, organization and application of computers and information processing systems. Foundation courses teach the basics of hardware, software and their interrelationships. Practical courses emphasize the use of both microcomputers and large computers. The graduate is ready for immediate employment or for further graduate study.

The student may choose either one of the following two programs: (a) the computer science program leading to the bachelor of science in computer science degree described in the present section of this catalog, or (b) the computer engineering option leading to the bachelor of science in electrical engineering degree described in the electrical engineering section of this catalog (page 106). Both programs draw from the same core curriculum of computer courses and both require that the student take a balanced selection of software (programming languages, etc.) and hardware (computer architecture, minicomputer laboratory, etc.) courses, both programs also require the same basic mathematics, physics and chemistry courses.

The computer science undergraduate program is designed to provide the student with a program in computer science as well as with a minor in a second area. The core sequence consists of 33 credits in computer science. Additionally, the curriculum provides a sound foundation in mathematics, physics, chemistry and in the social sciences and humanities. A minor specialty consisting of a minimum of 12 credits in an integrated, well-defined area encourages the student to develop some depth of understanding in a field other than computer science. The minor specialty is chosen by the student in consultation with and approval of an academic adviser. The minor can be chosen from a broad range of areas in science, engineering, and humanities. (Typical examples of minors are given in the EE/CS Student Handbook.) Students with interest in both electrical engineering and computer science should consider the computer engineering option in electrical engineering. (See page 110.)

Transfer Students—Transfer students are accepted into the computer science B.S. program on the same basis described earlier in the catalog. In addition, the division requires that at least 18 credits in computer science be taken at the Institute.

Graduates of technology programs may be able to fulfill the requirements for the bachelor's degree in computer science in two to three-and-one-half years, depending on the scope and level of their previous education. Consult an undergraduate adviser for details.
### Curriculum for the Bachelor of Science Degree in Computer Science (for Freshmen entering 1983)

#### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
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<td>101</td>
<td>Calculus I</td>
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#### Sophomore Year

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<td>Appl. Diff. Equations</td>
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<td>103</td>
<td>Introductory Physics III</td>
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<td>103</td>
<td>Calculus III</td>
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<td>Contemp. History</td>
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#### Junior Year

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<tr>
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<td>Assy &amp; Machine Lang</td>
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<td>237</td>
<td>Computer Architecture</td>
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<td>233</td>
<td>Probability</td>
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<tr>
<td>206</td>
<td>Compilers</td>
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<td>237</td>
<td>Computer Lab.</td>
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<td>358</td>
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<tr>
<td>298</td>
<td>Computer Systems</td>
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<td>299</td>
<td>Computer Lab. II</td>
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<td>397</td>
<td>Sr. Seminar in CS</td>
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</table>

Total credits required for graduation: 128

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*Students shall complete a minimum of 30 credits in humanities and social science courses. Students must take HU 101 and HU 110, and either HU 200 or SS 104 or SS 140-141. Students who are placed in HU 103 on the basis of the English Composition Placement Test administered at the Polytechnic to all incoming students may substitute HU 200 for HU 103. Students placed in HU 108 or HU 109 must complete this noncredit writing course before taking HU 101 (or HU 103).

**In addition, the student is required to select an area of concentration (such as literature, communications, the arts, philosophy, or comparative religion in the Department of Humanities, or political science, economics, history, anthropology, or psychology in the Department of Social Sciences) and to elect at least three courses in this concentration, in consultation with an adviser. A modern language may be chosen as a suitable concentration, but a student without prior knowledge of the language should devote at least 12 credit hours to the subject.

For the remaining credits in the humanities/social science requirements, the student should select courses in areas other than that of the concentration.

*CS 297 (1.3.2) may be replaced by EE 188 (2.3.3).*

**The elective credits should be from engineering and/or science. A programming course in another language is not an acceptable elective.

The minor specialty consists of a substantial concentration in a particular subject area other than computer science, approved by the departmental adviser. Examples of acceptable minor areas are statistics, systems analysis, operations research, controls, communications, psychology. Other minors may be arranged to satisfy the particular interest of the student. (Typical examples of minors are given in the FSCS Student Handbook.)
Transfer credits granted for graduates of programs at other schools are subject to frequent changes, based on reevaluation of content and level. Thus, students completing the same program, but in different years, may receive different amounts of transfer credit. Consult the computer sciences undergraduate adviser for current information. Transfer students must arrive and present their records for evaluation at least one week before the regular registration period for their first semester.

Senior Honor Students—A full-time day student whose performance in the first three years is outstanding will be named as a senior honor student and, in consultation with the adviser, is permitted to replace some of the required senior technical courses by other courses, usually more advanced, which are directed to the student's professional goals.

DEPARTMENTAL STANDARDS AND PROBATION

To earn a degree in computer science, students must earn a minimum C average (2.0 grade point average) in all technical courses: mathematics, physics, computers and engineering.

Students are automatically placed on departmental probation if their semester or cumulative technical average is less than 2.0, if they receive C- or less in any sophomore year computer science course or if they fail to obey course prerequisites. Students on probation must consult with their advisers during registration week prior to the beginning of each term. They may be required to repeat courses in which they have earned a grade of C- or less or an incomplete, to postpone an advanced course, to take a special program of courses to improve their understanding, or to withdraw from the department in cases of repeated departmental probation. Almost without exception, students earning a C- or less in CS 111 or CS 203 will be required to repeat the course. Likewise, a student who earns a combined average C- or less in all technical courses during one semester, or in a closely-related sequence of courses, will almost invariably be required to repeat some of these courses.

GRADUATE STUDY

The Division of Computer Science offers master's and doctor's degree programs in computer science, and a master's degree program in information systems.

The computer science master's program is intended to develop competence in basic areas such as information structures, programming languages, computer design and organization, compilers and translators, operating systems, artificial intelligence, interactive computer graphics, information retrieval, data base management, switching theory, theory of computation, numerical analysis and software engineering.

The information systems master's program is intended to provide graduate-level instruction for students interested in pursuing professional work in the development, specification and management of information and data processing systems.

Both programs are specifically structured to enable the graduate to keep abreast of the developments in the chosen discipline and to interact with other disciplines.

Students in both programs may extend their studies into related areas such as operations research, mathematics, electrical engineering, management, statistics and economics, in accordance with individual interests.

Outstanding students are advised to apply for financial aid in the form of a research fellowship, teaching fellowship or partial tuition remission.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

Entrance Requirements—For entrance to the master of science degree programs, an undergraduate degree in computer science, mathematics, science or engineering, with a superior undergraduate record, from an accredited institution, is desirable. Applicants having degrees in other fields will be considered for admission on an individual basis. Generally, entering students are expected to have a knowledge of mathematics through calculus. Additional entrance requirements for the two M.S. degree programs are as follows:

1. At least one year of university-level science.
2. A working knowledge of a higher-level programming language (such as PL/I, ALGOL, PASCAL, LISP, etc.)
3. A basic understanding of computer fundamentals, such as: computer organization and operations, data structures, assembly language programming, elements of logic and automata, computer architecture.

It is anticipated that entering students with B.S. degrees in computer science as well as students with degrees in technical areas and strong minors in computer science from an accredited institution will satisfy the entrance requirements for the M.S. degree programs.

Students having superior academic credentials but lacking sufficient background will be required by the divisional director to take additional preparatory courses, as specified from the available computer science undergraduate courses and/or from the series of five graduate orientation courses, CS 530, CS 540, CS 550, CS 560, CS 580. The successful completion of the specified preparatory courses with a B average or better is a necessary condition for admission to degree status. No 600 level computer science courses may be taken prior to satisfying the required orientation courses, without written permission of the CS graduate adviser.

The demonstrated ability to communicate in written and spoken English is an essential ingredient for success in pursuing graduate studies in computer science and information systems and is required for degree status. Foreign students and others for whom English is a second language should plan to take HU 008 and HU 103 (as determined by the English Composition Placement Test administered by the Department of Humanities prior to
Admission with advanced standing is accepted in accord with Polytechnic regulations published elsewhere in this catalog. A maximum of 9 units may be applied to the M.S. degree for previous graduate work at an acceptable institution.

Degree Requirements—To satisfy the requirements for the master's degrees, the student must complete a total of 36 units as described below, with an overall average of B. In addition, a B average is required in specified groups of courses, as indicated below.

Students with a strong undergraduate computer science background may be allowed to replace required courses with more advanced electives. Permission of the graduate adviser is required.

Master of Science (Computer Science major) Units

1. Core Requirements (B average required) 15
   - CS 603 Information Structures and Algorithms
   - CS 613 Computer Architecture I
   - CS 623 Operating Systems I
   - CS 637 Programming Languages
   - CS 641 Compiler Design and Construction I

2. One of the following three courses: 3
   - CS 675 Theory of Computation
   - MA 821 Numerical and Approximate Analysis I
   - A course in modern algebra or other graduate-level mathematics course, as approved by an adviser.

3. Two one-year course sequences from the list: 6 - 12
   - CS 603, CS 604 Design and Analysis Algorithms I, II
   - CS 605, CS 607 Software Engineering I, II
   - CS 613, CS 614 Computer Architecture I, II
   - CS 623, CS 624 Operating Systems I, II
   - CS 641, CS 642 Compiler Design and Construction I, II
   - CS 661, CS 662 Artificial Intelligence I, II
   - CS 671, CS 672 Switching and Automata I, II

4. Approved elective courses of which a maximum of 6 units may be a thesis 6 - 12

Thesis: Exceptional students may elect to write a master's thesis, for which no more than 6 units toward the degree may be earned. Such students should find an appropriate adviser who has agreed to monitor the thesis research. Such research need not be original, but should adequately demonstrate the student's proficiency in the subject material. A defense of the master's thesis with at least three professors in attendance is required.

**Master of Science (Information Systems major) Units**

Required Courses 27
- CS 603 Information Structures and Algorithms
- CS 606 Software Engineering
- CS 608 Data-Base Management Systems
- CS 609 Information Analysis and System Design I
- CS 623 Operating Systems I
- IE 600 Engineering Economic Analysis
- MA 562 Statistics
- MG 601 Organizational Behavior
- MG 810 Project Planning and Control

Electives 9
- Three courses as approved by an adviser, including at least one course from each of the following groups
  - Group A: CS 610, 616, 624, 633, 637, 653, 661
  - Group B: IE 614, 619, 627, 628, MG 606, 624, 762, 820

**REQUIREMENTS FOR THE DOCTOR'S DEGREE**

Graduate students who have exhibited a high degree of scholastic proficiency and have given evidence of ability for independent scholarly work may consider extending their goals toward the degree of doctor of philosophy (computer science major). The requirements for admission to the program include the following:

1. A B.S. degree in science, engineering or management from an accredited school and a superior academic record.

2. An M.S. degree or one year of graduate work in an analytically based area, and a superior academic record.

On admission to the program, the student must submit for approval a plan of study consistent with the Ph.D. requirements shown below. Further details concerning procedure are contained in the Guidance for Ph.D. Students brochure available from the Division of Computer Science.

1. A minimum of 90 units of graduate work beyond the B.S. degree, including 24 units of dissertation.

2. Qualitative rather than quantitative considerations will determine the final approval of the program of graduate studies; however, the following should be included:

   a. The basic M.S. requirements in computer science.
   b. A major concentration in some computer science area.
   c. Appropriate supporting courses in noncomputer areas, for breadth.
   d. One meaningful minor concentration in an area other than computer science (a minimum of four courses).

Requirements b. and c. must be approved by the Division of Computer Science; requirement d. must be approved by the Division of Computer Science or by a minor adviser.
3. Qualifying examinations consisting of three or four written examinations, generally covering topics corresponding to the M.S. requirements.

4. Presentation of a final seminar talk on the subject of the dissertation, at such time as the thesis adviser deems appropriate.

5. Preparation and defense of a scholarly dissertation that embodies original research contribution.

UNDERGRADUATE COURSES

Students are advised to consult the Departmental Student Manual and the Registration Bulletin for changes in courses, course content and prerequisites in effect subsequent to the publication of this catalog.

General Prerequisite: Students may not register for any junior- or senior-level courses until every freshman requirement is completed.

CS 100 Introduction to Computer Programming 3:0:3
Introduction to computers and development of fundamental understanding of their use. Each use of computer permits immediate solutions to simple engineering problems. Development of more complex programming techniques for use in subsequent engineering and computer courses. FORTRAN language used.

CS 111 Computer Programming I 3:0:3
Types of languages, problem-solving, algorithms, flow charts, Basic PLI instructions, simple programs, programming style, structured programs. Character and string handling, arrays, built-in functions, function and subroutine procedures. Problems assigned from several disciplines are solved on the Polytechnic computer.

CS 203 Computer Programming II 3:0:3
Programming in PASCAL, data types, assignments, loops, and conditional statements; arrays, records, sets, files, and pointers; functions and procedures. Methods for the design of high-quality programs. Elements of ADA. Prerequisite: CS 111.

CS 204 Introduction to Data Structures 3:0:3

CS 205 Assembly and Machine Language Programming 3:0:3

CS 206 Compilers 3:0:3
Grammars, lexical analysis, parsing algorithms, intermediate language, storage assignment, push-down stacks and run-time organizations. A large programming project is required. Prerequisites: CS 204 and CS 205.

CS 211 COBOL Programming 3:0:3
Computing using ANSI-COBOL for simple and complex business problems. Structured programming used throughout. Creating, use and updating sequential, indexed and relative data files on magnetic tapes and disks. Report writer and table handling modules in COBOL. Batch processing and time sharing processing. Prerequisite: CS 100 or CS 101 or CS 111.

CS 236 Switching Circuits and Digital Systems 3:0:3
Introduction to concepts of switching theory and digital systems. Number representations, arithmetic operations, coding, Boolean algebra, combinational circuits, logical design, sequential machines, state diagrams, clock mode and pulse mode systems, state reduction, machine synthesis. Prerequisite: CS 100 or CS 101 or CS 111.

CS 237 Introduction to Computer Architecture 3:0:3
Computer organization, arithmetic and logical operations, fixed and floating point systems. Registers, logical modules, memories, input-output devices. Introduction to a hardware specification language. Analysis of a complete digital computer employing hardware and microprogrammed control. Prerequisite: CS 236.

CS 238 Computer Systems 3:0:3
Introduction to operating systems, memory management techniques, paging, virtual memory. Multiprogramming and time-sharing systems. Concurrency, interactive and real-time systems. Interrupts, file structures, and introduction to data bases. Overview of practical systems for small and large machines. Prerequisites: CS 204, CS 205 and CS 237.

CS 240 Electronic Music Composition* 2:3:3
Analysis of representative works of electronic music from musical and technical viewpoints. Notational systems. Physics of musical sound generation by conventional acoustical instruments and by electronic systems. Techniques of sound recording, tape editing and electronic sound synthesis by analog, digital and hybrid integrated circuits. Creation of original composition. Enrollment limited. Prerequisites: interest in music, some knowledge of electronic circuits and computers.

CS 297 Computer Laboratory I 1:3:2
A series of required experiments provides an introduction to small computers. Computer circuit techniques. Small computer assembly language programming. Microcomputer and microcomputer organization and operations. Lab fee required. CoPrerequisite: CS 237.

CS 299 Computer Laboratory II 1:3:2
An introduction to the use of small computers as systems components. Interrupt programming concepts. Analog signal interfacing and real-time, closed-loop systems. Independent learning and hands-on experience with different small computers are provided by projects involving such subjects as computer graphics, light intensity control and motor speed control. Lab fee required. Prerequisites: CS 297 and CS 298.

CS 306 Software Design and Engineering 3:0:3
Introduces the techniques used to specify, design, test and document medium and large software systems. Design techniques include: structured programming, top-down and bottom-up design, defensive programming, documentation using HiPO diagrams, pseudocode and flowcharts. Path testing, exhaustive test models and construction of test data. Introduction to software tools. Students term projects involve group software development. Prerequisites: CS 203 plus junior status.

CS 308 Introduction to Database Systems 3:0:3
The effective management and utilization of data. Objectives of DBMS, data independence, integrity, security. Organization and access techniques, architecture, data definition and manipulation languages. Data models, hierarchical, network, relational. Practical applications of state-of-the-art techniques, foundations and underlying theories. Prerequisite: CS 204.
Graduate courses in computer science are offered on each campus on a regular basis, annually, or in two-year or three-year cycles. Consult the Graduate Student Manual for these scheduling cycles as well as for information about day offerings and the summer program. The Computer Science Graduate Office, sent out to continuing students prior to each registration, contains the latest information on Selected Topics course offerings, curriculum and course revisions.

CS 531 Introduction to Digital Computing 2'12:0:3
First course in computing, concentrating on analysis of problems for computer solution. Organization of computer: structure and properties of algorithms and programs, flowcharting, debugging and verification, documentation, data representation, numerical error analysis. FORTRAN IV language used. Prerequisite: graduate status. No credit will be allowed for CS 531 toward graduate degree in computer science, information systems or other degree programs administered by the Department of Electrical Engineering and Computer Science. Also listed under IE 601

CS 532 COBOL Programming 2'12:0:3
Data processing and file processing using ANSI-COBOL. Structured programming used throughout. More than standard COBOL features such as report writer and macro level table handling are covered. Creating, use and updating of files on tapes and disks. Batch and Time Sharing Processing. Prerequisite: MG 602 or knowledge of computer programming. No credit will be allowed for CS 532 toward graduate degree in computer science, information systems or other degree programs administered by the Department of Electrical Engineering and Computer Science. Also listed under MG 635

CS 503 Design and Analysis of Algorithms I 2'12:0:3
Organization and processing of various types of information. Trees, traversals, scanning, heaps, binary search, height-balanced, B-trees, Trees, search, hash decision, symbol, lists and strings. Advanced searching and sorting techniques. Prerequisite: CS 204 or CS 440

CS 504 Design and Analysis of Algorithms II 2'12:0:3
Analysis of computational complexity. Theory of NP-completeness and approaches to the exact and approximate solution of NP-complete problems. Linear and integer programming techniques. Dynamic programming. Combinatorial optimization. Prerequisite: CS 603

CS 506 Software Engineering I 2'12:0:3
Software development, modeling tools, techniques: design, estimation, testing, reliability, management. Design and analysis: top-down, modular structured, HiPO diagrams, cause-effect graphs. Probabilistic models: complexity, number of errors, reliability, availability, testing, critical, integration, paths, exhaustive, regression. Management costs: productivity, controls. Prerequisites: MA 223 and one of the following: CS 623, CS 629, CS 641

CS 507 Software Engineering II 2'12:0:3
A continuation of material begun in CS 506 with emphasis on software development tools and the management of software projects: systems specification, estimation, and control of software costs and program productivity. Students will be organized into project groups and plan and design a software system using manual and computerized development tools. Class presentations, exams and term project. Prerequisite: CS 506.

CS 536 Microprocessors 3'12:0:3
Block diagram description of the architecture of a typical microprocessor. Registers and ALU of the CPU, interfacing components, bus structure, input-output techniques, priority interrupt schemes. Program techniques. Prerequisites: CS 205 and CS 237

CS 597 Senior Seminar and Project in Computer Science 2'12:0:2
Topics of general interest prepared, reported and discussed by faculty and students. Project proposals prepared and presented by students. Prerequisites: CS 206 and CS 297

CS 598 Senior Project in Computer Science 1'12:0:3
Term project. Several students work as group with staff member and graduate students on topic of interest. Written report and presentation required. Prerequisite: CS 597. Corequisite: CS 299 or EE 189

ORIENTATION COURSES

The graduate courses listed in this section were formulated to accommodate the needs of students who wish to pursue graduate studies in computer science, but who lack sufficient undergraduate preparation. No credit will be allowed for any of these courses toward graduate degrees in computer science, information systems or other degree programs administered by the Department of Electrical Engineering and Computer Science.

Submission of substantial computer programming assignments is required in all these courses except CS 560.

CS 530 Introduction to Computer Science 2'12:0:3
Concentrated orientation course for students interested in pursuing graduate work in computer science. Types of languages, problem-solving, algorithms, flow charts. Basic PL/I instructions, programs, programming style, structured programming. Character and bit strings, arrays, built-in functions, function and subroutine procedures. Assigned problems. Prerequisite: graduate status.

CS 540 Elements of Data Structures 2'12:0:3
Concentrated orientation course for students entering computer science from another field. Internal representation of the stack, queue, list and their applications. Trees and graphs. Recursive programming techniques. Internal searching and sorting. Prerequisite: CS 530

CS 550 Assembly Language Programming 2'12:0:3
Assembly language, system organization and architecture of the PDP-11. Internal representation of numeric and character data, Machine language programming, symbol tables, and the assembler, Stack, subroutines, recursion. Implementation of program environments, block structure, position independent and re-entrant code, Linking, loading and memory mapping. I/O programming. Prerequisite: CS 530.

CS 550 Introduction to Logic and Automata 2'12:0:3
Automata and switching theory. Boolean algebra, truth tables, combinational circuits, logical design, gate realizations, Sequential machines, state diagrams, tables, state equivalence, machine synthesis. Prerequisite: graduate status.

CS 580 Introduction to Computer Architecture 2'12:0:3
Computer organization, arithmetic and logical operations, fixed and floating point systems, registers, logical modules, memories, input-output devices. Introduction to a hardware specification language. Analysis of a complete digital computer employing hardwired and microprogrammed control. Prerequisites: CS 550 and CS 570.
CS 608 Principles of Database Systems 2 1/2:0:3
Database management system overview. Data independence and abstraction, physical database, organization, and access methods. Data models, entity-relationships, network, hierarchical, and relational structures. Relational model design theory, functional multivalued dependencies, normalization, and query language optimization. Concurrent operation in centralized and distributed database systems. Prerequisite: CS 609.

CS 609 Information Analysis and System Design I 2 1/2:0:3
Introduction to the system life cycle of a computer information system. System life cycle management. Basic analysis tools, determining system economics. Logical system design. Introduction to physical system design. Prerequisite: CS 530.

CS 610 Information Analysis and System Design II 2 1/2:0:3

CS 613 Computer Architecture I 2 1/2:0:3
Introduction to digital computer organization and architecture. Arithmetic operations; adders, accumulators, multipliers, dividers, organization and control of computer, minicomputer architecture, machine languages and systems principles (knowledge of a programming language required). Prerequisites: CS 550 and CS 560. CS 237 recommended.

CS 614 Computer Architecture II 2 1/2:0:3
Further development of topics in machine organization and architecture. Microprogramming and microprocessors, hardware/software tradeoffs, parallel computers and distributed processing, stack computers, overlap and pipeline processing, array processors, computer network. Prerequisite: CS 613.

CS 615 Microprocessor 2 1/2:0:3
Advanced microprocessor architectures and techniques including multiprocessor systems, memory management, and real-time considerations. VLSI implementation, bit-slice microprogrammed systems. Prerequisite: CS 613.

CS 623 Operating Systems I 2 1/2:0:3
Introduction to the structure of multiprogramming computer operating systems. Memory hierarchies, memory management, static and dynamic allocation, virtual memory, disk scheduling, swapping and synchronization. Prerequisites: CS 540 and CS 550. CS 237 or CS 613 are strongly recommended.

CS 624 Operating Systems II 2 1/2:0:3
Continuation of CS 623. Overall organization of multiprogramming operating systems, processor and management scheduling, deadlock detection and avoidance, file system management. Prerequisite: CS 623.

CS 633 Information Retrieval and Natural Language Processing 2 1/2:0:3

CS 635 Principles of Data Communication Networks 2 1/2:0:3

Also listed under EL 635

CS 637 Programming Languages 2 1/2:0:3
The structures, notations, and semantics of conventional programming languages. Introduction to the analysis and design of user-oriented application languages. Advanced concepts of input and output. Prerequisites: CS 540 and CS 550.

CS 641 Compiler Design and Construction 2 1/2:0:3
Organization of compiler, symbol table organization, lexical analysis, syntax analysis, object code generation, introduction to code optimization techniques. Internal representations of parser and source program. Polish notation, trees, translation of arithmetic expressions and program constructs. Prerequisites: CS 540, CS 550, CS 560.

CS 642 Compiler Design and Construction II 2 1/2:0:3
Further consideration of code optimization techniques. Formal languages and grammars. Introduction to translator systems. Prerequisite: CS 641.

CS 651 Computer Graphics and Image Processing* 2 1/2:0:3
Introduction to computer graphics. Vector, curve, and character generation. Display components and algorithms, data structures, discussion of digital image processing. Data analysis and representation techniques. Prerequisite: CS 613.

CS 653 Interactive Computer Graphics* 2 1/2:0:3

CS 658 Artificial Intelligence I 2 1/2:0:3

CS 662 Artificial Intelligence II 2 1/2:0:3

CS 653 Artificial Intelligence and Pattern Recognition* 2 1/2:0:3

CS 671 Switching and Automata I 2 1/2:0:3
CS 672 Switching and Automata I
Further development of theory of finite-state machines. State assignments, partitions with substitution property and partition pairs, machine decompositions, shift-register realizations, regular expressions, linear machines, information losslessness, diagnosing and homing experiments, machine identification and testing. Prerequisites: CS 671.

CS 673 Formal Languages and Automata Theory
Introduction to generative grammars, characteristics of regular, context-free, context-sensitive and type-zero grammars. Relationships between languages and machines. Finite-state machines, push-down automata, Turing machines. The halting problem, solvable and unsolvable linguistic question. Prerequisite: CS 671.

CS 675 Theory of Computation
Paradoxes associated with naive set theory and infinite sets. Models of computation and computability. Turing machines, Post machines, formal languages, finite state machines and automata. Recursive functions applied to flowchart schemas and structured programming. Lambda calculus as a notation for functions. Predicate logic as a programming language. Automated theorem proving using resolution and unification. Prerequisite: Graduate status.

CS 901-912 Selected Topics in Computer Science
Topics of current interest in computer science. Recent offerings include: computer aided design; fault tolerant computing, automation techniques, software economics, parallel processing, program methodology. Specific topics announced in advance. (See computer science graduate mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

Courses in Selected Topics bearing the same numbers may be repeated for credit provided the topics are different, subject to adviser’s approval.

CS 941-942 Readings in Computer Science I, II
Intended primarily for students who wish to study in a specialized area under the supervision of a faculty member. Courses are open only in unusual cases to outstanding students who have completed at least 30 credits or graduate study and who are available for weekly consultation with an adviser. An examination or term report is required. Prerequisite: degree status and permission of director of division.

CS 996 Advanced Projects in Computer Science
This course permits the student to perform research in computer science somewhat less in scope than a master’s thesis. The acceptance of a student by a faculty adviser is required before registration. An oral examination on the project report is required. Prerequisite: degree status.

CS 997 Thesis for Degree of Master of Science
Exceptional students may elect to write a master’s thesis for which no more than 6 units toward the degree may be earned. Such research should demonstrate the student’s proficiency in the subject material. Oral thesis defense with at least three professors in attendance, plus a formal, bound thesis volume are required. Thesis registration must be continuous. Prerequisite: degree status and satisfactory grades in prescribed courses.

CS 999 Dissertation for Degree of Doctor of Philosophy
Original investigation of computer science problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: degree candidacy, passing of qualifying examination and approval of the computer science graduate adviser.

FACULTY

Martin L. Shooman, Professor of Electrical Engineering and Computer Science, and Director of Division of Computer Science
S.B., S.M., Massachusetts Institute of Technology; D.E.E., Polytechnic Institute of Brooklyn
Software engineering, system reliability and safety

Robert R. Boorstyn, Professor of Electrical Engineering and Computer Science
B.E.E., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn
Computer communication networks, telecommunications

Melvin Klerer, Professor of Computer Science
B.A., M.S., Ph.D., New York University
Programming systems, languages, artificial intelligence

Arthur E. Laemmel, Professor of Electrical Engineering and Computer Science
B.E.E., Polytechnic Institute of Brooklyn
Computer architecture, coding, digital circuits

James T. LaTourrette, Professor of Electrical Engineering and Computer Science
B.S., California Institute of Technology; M.A., Ph.D., Harvard University
Quantum electronics, computer software

Jack Mechanik, Industry Professor and Director, Center for Digital Systems
B.Sc (Eng), University of Witwatersrand (South Africa); M.S.E.E., Stanford University
Fault tolerant architectures, distributed processing, system integration methodology

Joel B. Snyder, Industry Professor
B.E.E., M.E.E., Polytechnic Institute of Brooklyn
Microprocessor systems, data acquisition and transmission, signal processing

Stanley Preiser, Professor of Mathematics and Computer Science
B.S., CCNY; M.S., Ph.D., New York University
Numerical analysis, applied mathematics, algorithms, system performance evaluation

Edward J. Smith, Professor of Electrical Engineering
B.E.E., Cooper Union; M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Computer organization, switching and automata
Ronald J. JueIs, Associate Professor of Computer Science
B.E.E., M.E.E., Polytechnic Institute of Brooklyn; D.Sc., Stevens Institute of Technology
Computer architecture, microprocessor systems, VLSI design

Aaron Kershenbaum, Associate Professor of Computer Science
B.S., M.S., Polytechnic Institute of Brooklyn
Ph.D., Polytechnic Institute of New York
Computer communications, algorithms

A. David Klappholz, Associate Professor of Computer Science
B.S., Massachusetts Institute of Technology; M.S.E., Ph.D., University of Pennsylvania
Parallel processing, computer architecture

Paul F. Pickel, Associate Professor of Mathematics
B.S., Ph.D., Rice University
Infinite groups, computer graphics, educational applications of computers, mathematical programming

Henry Ruston, Associate Professor of Electrical Engineering and Computer Science
B.S.E. (Math), B.S.E. (EE), Ph.D., University of Michigan;
M.S., Columbia University
Software engineering, programming, circuit theory

Basil S. Maglaris, Assistant Professor of Electrical Engineering and Computer Science
Dipl. EE, National Technical University of Athens (Greece); M.Sc., Polytechnic Institute of New York; Ph.D., Columbia University
Computer communication networks, performance evaluation of computer systems

Wang-Chuan TsaI, Assistant Professor of Computer Science
B.S., M.S., National Chiao-Tung University, Ph.D., University of Illinois
Distributed database, compilers

Joseph S. Fulda, Instructor of Computer Science
B.S., CCNY; M.S., New York University
Modeling, artificial intelligence, paradigms of computer science, computer science education

Linda Anne Grieco, Instructor of Computer Science
B.A. (Math), Hofstra University, Ph.D. (Math), Rutgers University, M.S. (CS), Polytechnic Institute of New York
Programming and computer software

Michael J. Post, Instructor of Computer Science
A.B., Columbia University; M.S., Polytechnic Institute of New York
Coding theory, operating systems, high-level architecture

Evelyn Gall Roman, Instructor of Computer Science
B.S., Ph.D., CCNY
Artificial intelligence, robotics, applied mathematics

ADJUNCT FACULTY

Ron Ashany, Adjunct Professor
B.S.E.E., Technion; M.S., Ph.D., Polytechnic Institute of New York

William Bouricius, Adjunct Professor
B.A., Hastings; M.A., University of Wisconsin; Ph.D., Yale

Li-hsiang Cheo, Adjunct Professor
B.S., Taiwan College of Engineering; M.S., University of California at Berkeley; Ph.D., New York University

Barry V. Gordon, Adjunct Professor
B.E.E., M.E.E., New York University

Fred Grossman, Adjunct Professor
B.S., Polytechnic Institute of Brooklyn; M.S., Ph.D., New York University

Robert Hong, Adjunct Professor
B.S., (I.E.) Columbia University; B.S. (EE.), Cooper Union

Maurice Karnough, Adjunct Professor
B.S., CCNY; M.S., Ph.D., Yale

Robert L. Schoenfield, Adjunct Professor
B.A., New York University; B.S., Columbia University;
M.E.E., D.E.E., Polytechnic Institute of Brooklyn

Walter Vassiliki, Adjunct Professor
B.A., Rutgers University, M.A., University of Maryland; Ph.D., New York University

David R. Doucette, Adjunct Associate Professor
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn

Robert Flynn, Adjunct Associate Professor
B.S., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn

Roy S. Freedman, Adjunct Associate Professor
B.S., M.S. (Math), M.S., (EE.), Ph.D, Polytechnic Institute of New York

Kenneth R. Aupperle, Lecturer
B.S., M.S., Polytechnic Institute of New York

James Basile, Lecturer
B.S., M.A., Ph.D., State University of New York

Eleanor Boekman, Lecturer
B.S., New York University, M.S., Polytechnic Institute of New York

Charles J. Bontempo, Lecturer
B.S., M.S., University of Maryland

William Chuang, Lecturer
B.S., Chung-Yung College; M.S., Ph.D., Polytechnic Institute of New York

Marchiello Distasio, Lecturer
B.S., Oswego, Ph.D., Michigan State University
William Edelson, Lecturer
B.E.E., CCNY; M.S., New York University; Ph.D., Polytechnic Institute of New York

George E. Estes, Lecturer
B.S., Stanford University; M.S. Polytechnic Institute of New York

Harry Goldberg, Lecturer
B.S., Queens College; M.S., Polytechnic Institute of New York

Daniel J. Gorman, Lecturer
B.S., University of Massachusetts (Amherst); M.S., Columbia University

Ronald B. Greenwald, Lecturer
B.E., Pratt Institute; M.S., Columbia University

Lewis Herzberg, Lecturer
B.E.E., CCNY; M.S.E.E., Ph.D., Polytechnic Institute of Brooklyn

David Jacobson, Lecturer
B.A., Ph.D., Yeshiva University

Lawrence L. Leff, Lecturer
B.S., Polytechnic Institute of New York

Leonard Librizzi, Lecturer
B.E.E., CCNY; M.E.E., Polytechnic Institute of Brooklyn; M.S., Polytechnic Institute of New York

Howard W. Loewenstein, Lecturer
B.C.E., CCNY; M.S., Polytechnic Institute of Brooklyn

Matthew J. Miner, Lecturer
B.S., Polytechnic Institute of New York

Marsha Moroh, Lecturer
B.S., Dickinson College; M.S., New York University; Ph.D., Polytechnic Institute of New York

Robert O'Hara, Lecturer
B.A., Pennsylvania State University; M.S., Union College

Dov Torenberg, Lecturer
B.S., M.S., Polytechnic Institute of New York

Evriclea Voudouri, Lecturer
B.S., New York Institute of Technology; M.S.E.E., M.S.C.S., Ph.D., Polytechnic Institute of New York
This core curriculum represents a new vision of liberal education. It is based on the idea that a well-educated liberal arts undergraduate should be exposed to the man-made, in both its technological and traditional forms.

With special permission from either the Department of Social Sciences or the Department of Humanities and Communications, students majoring in other disciplines will be able to take the following courses in this curriculum to satisfy their humanities and social science requirements:

Curriculum for the Bachelor of Science Degree in Social Sciences or the Humanities

Fall
Freshman Year

<table>
<thead>
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<th>No.</th>
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<th>Credits</th>
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<tr>
<td>HU 101</td>
<td>College Composition</td>
<td>3</td>
</tr>
<tr>
<td>SS 104*</td>
<td>Main Themes in Contemporary World History</td>
<td>3</td>
</tr>
<tr>
<td>LA 110</td>
<td>Technology and Society in Historical Perspective</td>
<td>3</td>
</tr>
<tr>
<td>LA 120</td>
<td>The World of Mathematics and Computers I</td>
<td>4</td>
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<tr>
<td>PE 101</td>
<td>Physical Education I</td>
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Sophomore Year

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<td>The Biological World</td>
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<tr>
<td>PE 103</td>
<td>Physical Education III</td>
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<td>CS or EL*</td>
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<td>12</td>
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Junior Year

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<th>Subject</th>
<th>Credits</th>
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<tbody>
<tr>
<td>LA 141</td>
<td>Materials and Social Issues</td>
<td>3</td>
</tr>
<tr>
<td>LA 142</td>
<td>Machines: Extensions of Man</td>
<td>3</td>
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<tr>
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Senior Year

<table>
<thead>
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<tr>
<td>LA 150</td>
<td>The Making of Connections</td>
<td>3</td>
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<tr>
<td>LA 160</td>
<td>Senior Seminar and Thesis I**</td>
<td>3</td>
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Spring

<table>
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<tr>
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<tbody>
<tr>
<td>HU 200*</td>
<td>Introduction to Literature</td>
<td>3</td>
</tr>
<tr>
<td>LA 121</td>
<td>The World of Mathematics and Computers II</td>
<td>4</td>
</tr>
<tr>
<td>LA 130</td>
<td>The Physical World</td>
<td>4</td>
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<tr>
<td>PE 102</td>
<td>Physical Education II</td>
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</tr>
<tr>
<td>CS or EL*</td>
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<td>6</td>
</tr>
</tbody>
</table>

*CS = Concentrated studies in major; EL = electives
COURSES

LA 110 Technology and Society in Historical Perspective 3:0:3
An examination of the role of secular and religious values in shaping technology, and the subsequent impact of technology on events and values. Psychological profiles of inventors and innovators. Invention, innovation and diffusion of technology. The impact of the assembly line, telecommunications, computers, plastics, television and rockets. Emerging trends: miniaturization, robotics, biotechnology and space industrialization.

LA 120-121 The World of Mathematics and Computers I & II each 4:0:4
An introduction to the principles of finite mathematics and calculus taught in conjunction with learning to use computers. Instruction in BASIC and other languages. Students are taught to run programs which elucidate the following mathematical concepts: number system, limits, integration, probability, statistics, derivatives and matrices.

LA 130 The Physical World 4:0:4
This course is designed to convey the excitement of the human experience called "physical science," and its connections with the issues that concern all men and women — the impact of science on technology and civilization, culture and world views. Topics include: space-time-matter, motion and force, work and energy, states of matter, the microscopic and macroscopic approach in the science of chemistry. Experiments are conducted at the discretion of the instructor.

LA 131 The Biological World 3:3:4
An investigation of the origin of life and the characteristics of living things. Studies include an examination of evolution and its mechanisms which have resulted in the ecological diversity of the biosphere. The effects of technology on ecology are addressed. Laboratory experiments and field trips are used to further elucidate these concepts.

LA 132 The Behavioral World 3:3:4
An examination of psychological concepts and methodologies central to understanding behavior. Topics: sensation and perception, acquisition and maintenance of behavior, social behavior, abnormal behavior. Students conduct experiments in signal detection, verbal learning, and social conditioning of judgments.

LA 140 Ethics and Technology 3:0:3
An examination of some basic ethical theories of human action and how these relate to technological making and using. Use is made of case studies representing various ethical problems as well as some classic ethical texts.

LA 141 Materials and Social Issues 3:0:3
An examination of the origins, properties and uses of metals, polymers and other materials. New frontiers in the development of materials. The impact of materials on contemporary society. Laboratory demonstrations throughout the course.

LA 142 Machines: Extensions of Man 3:0:3
An examination of machines in both their technical and human aspects. An analysis of work and power in relation to human beings, animals, and natural sources; the use of machinery to duplicate and extend human dexterity and skill. Discussion of the human aspects include the machine as metaphor: humanization vs. dehumanization by machines.

LA 143 Information, Communication and Society 3:0:3
Explores the nature of information, communication and their associated systems and technologies: fundamentals of information theory and information processing; cultural, economic and political implications of the communications-computer revolutions.

LA 144 Energy Technology and Social Issues 3:0:3
An integrated study of energy technologies and resources, their contemporary problems and future prospects. Review of basic physical principles; history of energy resources and technologies; contemporary energy technologies, with the social and ethical problems they pose, alternative technologies and social prospects for the future.

LA 150 The Making of Connections 3:0:3
An interdisciplinary seminar devoted to examining basic issues introduced by previous courses: questions concerning the relationships between machines and human nature, freedom and the individual in a technological society, technology and science, social justice and technological limits. Explores probable futures and alternative social policies in light of rapid scientific and technological change. For each offering, the specific focus of this seminar is determined by the instructor.

*Students may elect to take IS 140 (Language and Communication) and IS 141 (The Self and Society) in place of HU 200 and SS 104.

**Credit will be assigned for the fall and spring semesters upon successful completion of the project.

***Students may elect to major in a discipline other than their major. A minor may be in such fields as Information Management (12 credits), Computer Science (12 credits) or Life Sciences (14 credits).
LA 160-161 Senior Seminar—first semester 3:0:3
Thesis I & II—second semester 4:0:4
An individual research project culminating in a substantial paper.
Subject to be chosen by student in consultation with a thesis adviser.

FACULTY

William Blesser, Professor and Director of Bioengineering
George Bugliarello, President and Professor of Civil Engineering and Bioengineering
Edward Cassidy, Professor of Electrical Engineering
Carmine D’Antonio, Professor of Metallurgy
Duane DeVries, Associate Professor of English
Frederick Eirich, Distinguished Professor of Polymer Chemistry

Peter Grossman, Assistant Professor of Humanities and Communications
Donald Hockney, Professor and Head of Humanities and Communications and Director of Contemporary Liberal Arts Core Curriculum
Burton Lieberman, Associate Professor of Mathematics
Ernest M. Loebi, Professor of Physical Chemistry
Carl Mitcham, Associate Professor of Humanities
Shirley Motzkin, Professor of Biology
Kurt Salzinger, Professor of Psychology and Head of Social Sciences
A. George Schillinger, Associate Professor of Management and Operations Research
Romualdas Svedrys, Associate Professor of History of Technology
Richard Thorsen, Associate Professor of Mechanical and Aerospace Engineering
COOPERATIVE EDUCATION PROGRAM

The Cooperative Education Program provides students with practical work experience in industry, government and public service agencies.

Co-op is normally a five year undergraduate program which enables a student to combine the required number of classroom credits with approximately 20-24 months of work experience. The first and fifth years are spent on the campus in the conventional September to May study schedule, while the middle years, including summers, are devoted to alternating periods of training in industry and study on the campus.

For graduate students and undergraduate transfer students, the length of the program and sequence of alternation will be determined through faculty recommendation.

Students who are accepted into the program will start interviewing with participating Co-op companies during the semester prior to the first scheduled work experience. The Cooperative Education Office will be responsible for setting up the interviews. In most cases, the company interview will determine whether the student is hired as a Co-op employee.

Once on the job, the Co-op student employee will be paid a salary and, in most cases, receive company benefits. The student will be given work that is directly related to the student’s career goals and level of academic experience.

ELIGIBILITY

Prior to being placed on the initial Co-op work assignment, a student must:
• Achieve and maintain a 2.5 grade point average;
• Complete at least 30 credits of academic work with no course deficiencies.
• Participate in specialized Co-op seminars in career development (CP 101) and Technical Communications (CP 102). These seminars are required of all freshmen and sophomores prior to the first work assignment.

Transfer students are required to:
• Complete one semester of study at Polytechnic prior to beginning the first work period.
• Attend one semester of the required Co-op seminar, either CP 101 or CP 102.
• Achieve a 2.5 grade point average.
• Obtain departmental approval for program participation.

Graduate students are eligible to participate at any time after scheduling the work experience with a faculty adviser.

UNDERGRADUATE AND GRADUATE REGISTRATION

Regarded as a professional practice period, the Co-op courses are non-credit but will be recorded on the official transcript as either S or U on a non-credit basis. The grade of “satisfactory” or “unsatisfactory” will be based on the employer evaluation of the student and the cooperative education coordinator evaluation. The transcript notation will include the Co-op course number, the employer name and the functional department to which the student is assigned.

A $25 registration fee is charged for each work period.

The Cooperative Education courses are assigned to each student in sequence, starting with Co-op 10 to Co-op 14 by the Cooperative Education Office.

The level of the Co-op course number is used as an administrative device to keep track of the actual number of work assignments completed by each student. A student entering into an industrial assignment after the freshman year will normally complete five work periods — Co-op 10 through Co-op 14—while a student entering after the sophomore year might be eligible to complete only two work periods, Co-op 10 and Co-op 11. The Co-op course number does not indicate the actual work assignment, which may vary, depending on the company’s product or service, and the student’s ability and interest. Some firms may assign a student according to current work load and the student’s level of experience and/or academic standing. Others have a formalized training program that all students are required to complete. A typical formalized training program might contain the following assignments:

Co-op 10—Shop on laboratory indoctrination. Rotating assignments to give the future engineer or scientist a working knowledge of production methods.

Co-op 11—Quality control or data acquisition. Working directly with a senior technician or engineer.

Co-op 12—Production engineering or testing. At this point the student is usually given a task for which he or she is totally responsible under the supervision of a senior engineer or scientist.

Co-op 13—Research or design. The student is exposed to engineering or scientific methods relating to the state of the art.

Co-op 14—Usually the student’s choice.
UNDERGRADUATE COURSES

CP 101 Cooperative Education Seminar I* 1:0:N.C.
The development and practice of pre-employment skills to specifically prepare students for their first and succeeding cooperative education work periods with industry and government. Methods of discovering fields in which individuals should find the greatest rewards in personal satisfaction and material gain, the techniques of resume writing and interviewing, adjusting of attitudes to adapt to varying conditions, making contacts with prospective employers, planning for advancement, and other problems bridging the gap between education and work will be examined. Seminars will be conducted by the Co-op staff, faculty and guest lecturers from industry.

CP 102 Cooperative Education Seminar II* 1:0:N.C.
The development and practice of skills in oral and written presentation in order to help the prospective Co-op students meet the demands of employers while on their work periods. The rudiments of technical report writing and public speaking will be explored.

*A grade of S (satisfactory) or U (unsatisfactory) will be recorded on the student record upon completion of each course; however, the course will not be computed in the Grade Point Average (G.P.A.), and is not required for graduation.

COORDINATORS

Ernest B. Recz, Associate Provost and Director of Career Services and Cooperative Education

Beatrice Hackenberg, Coordinator, Long Island Campus
B.S., SUNY-Empire State College

L. Kaye Griffith, Coordinator, Cooperative Education
B.B.A., University of Texas (San Antonio)

Michele E. Stewart, Coordinator, Job Development
B.S., SUNY-Stony Brook
ECONOMIC SYSTEMS

The program in economic systems is intended to develop in individuals a proficiency in the construction and implementation of economic models, both at the level of the individual firm and the entire economy. Such models provide engineering managers with important tools for decision making.

Starting with fundamental courses in engineering economics, microeconomic and macroeconomic decision models and econometrics, the student is encouraged to complement the program with related courses in methodology and practice. This may include work in industrial engineering, operations research, or management and the social sciences.

An undergraduate degree in engineering of science usually provides the necessary prerequisites for admission to the program. Further, undergraduates in economics and other quantitative social sciences are also encouraged to enter the program if their interests are in economic models. If competence in mathematics through calculus (MA 103) has not been attained, appropriate courses to remove this deficiency will be required on admission to the program.

Application should be made to the Department of Industrial Engineering and Operations Research with economic systems indicated as the area of specialization.

The graduate program in economic systems leads to the degrees of master of science and doctor of philosophy.

### REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
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<tbody>
<tr>
<td>A</td>
<td>Basic Required Courses¹</td>
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</tr>
<tr>
<td></td>
<td>IE 600</td>
<td>Engineering Economy</td>
</tr>
<tr>
<td></td>
<td>MA 153</td>
<td>Elements of Linear Algebra³</td>
</tr>
<tr>
<td></td>
<td>MA 561</td>
<td>Probability²</td>
</tr>
<tr>
<td></td>
<td>IE 601</td>
<td>Intro. to Digital Computing</td>
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<tr>
<td></td>
<td>IE 609</td>
<td>Statistics⁵</td>
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<td></td>
<td>IE 627</td>
<td>Oper. Res. - Deterministic Models³</td>
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<td>B</td>
<td>Required Courses</td>
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<td></td>
<td>IE 665</td>
<td>Macroeconomic Models</td>
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<tr>
<td></td>
<td>IE 666</td>
<td>Microeconomic Models</td>
</tr>
<tr>
<td></td>
<td>IE 674</td>
<td>Econometric Models &amp; Methods</td>
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<td>C</td>
<td>Major Electives: Select 4</td>
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<tr>
<td></td>
<td>MG 604</td>
<td>Managerial Accounting</td>
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<tr>
<td></td>
<td>IE 614</td>
<td>Modeling of Social Systems</td>
</tr>
<tr>
<td></td>
<td>IE 626</td>
<td>Oper. Res.: Stochastic Models³</td>
</tr>
<tr>
<td></td>
<td>IE 631</td>
<td>Linear Programming</td>
</tr>
<tr>
<td></td>
<td>IE 671</td>
<td>Bus. &amp; Econ. Forecasting</td>
</tr>
</tbody>
</table>

| IE 673  | Time Series: Forecasting & Control |       |
| IE 851  | Applied Regression & ANOVA         |       |

### D. Other Relevant Electives² | 15 units

Minimum total | 36 units

### REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

The general Polytechnic requirements for the doctor of philosophy degree are stated in this catalog under degree requirements.

Entrance to the doctoral program is contingent on passing the program's qualifying examination. This will consist of the Part I preliminary written examination and the Part II written examination. An examination in one foreign language is required; ordinarily French, German or Russian.

The doctoral program requires a minimum of 90 units beyond the bachelor's degree, including a minimum of 24 units of dissertation; no more than 30 units of dissertation may be counted in the minimum total.

After passing the written qualifying examination, the candidate will select a thesis adviser and prepare a formal proposal for the dissertation research. A thesis

¹ All group A courses are required, unless they are specifically waived by the adviser, because the student either (a) has taken an equivalent undergraduate or graduate course, or (b) passes a validation examination for the course. Up to three group A courses actually taken may be credited toward the degree requirement; if more than three must be taken, the degree requirements will be increased accordingly.

² Group D electives are to be chosen with the adviser's approval to bring total units to 36 plus any excess of Group A courses beyond 9 units. They may include thesis, additional courses from Groups B and C, or other graduate courses in this or other departments. Because of substantial overlap with IE courses, no credit will be given for MG 630, MG 631 and MG 635.

³ Certain introductory courses will be waived if the student takes specified advanced courses, for which full credit will be given:
    - For IE 627, IE 631 and either IE 632 or IE 665
    - For IE 626, IE 650 and either IE 618 or IE 619
    - For MA 153, MA 703, MA 837 or MA 838

⁴ Students who have not had a full course in probability are urged to take MA 561 or an equivalent course during the summer preceding their first term.

⁵ Students who have not had a full course in statistics are urged to take IE 609 or an equivalent course during the summer preceding their first term.
committee will be appointed to judge the merit of the proposed research. After approval of this proposal, the doctoral candidate shall register for research. On completion of the dissertation, the candidate must pass an examination in its defense.

CERTIFICATE PROGRAMS

A certificate program in economic systems, designed for the professional with work experience, is offered. Five courses, selected to meet the needs of the individual, are required to qualify for a certificate. Applicants for a certificate program must hold a bachelor's degree. On completion of the sequence with a B average or better, the individual is issued a certificate. Students who choose to work toward a master's degree are able, on admission, to apply all courses toward a certificate to the degree program. Additional information may be obtained from the department.

COURSE DESCRIPTIONS

All courses in Economic Systems are described in the industrial engineering section of this catalog.

FACULTY

Seymour Kaplan, Associate Professor of Operations Research and Management Science, Director of Economic Systems Program
Edward S. Cassedy, Professor of Electrical Engineering
John T. Chu, Professor of Operations Research and Management Science
Norbert Hauser, Professor of Industrial Engineering and Management Science
Walter Helly, Professor of Operations Research, and Head, Department of Industrial Engineering and Operations Research
John H. K. Kao, Professor of Industrial Engineering
Joachim I. Weindling, Professor of Operations Research and System Engineering
Anthony J. Weiner, Professor of Management
Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management
Melvyn L. Meer, Assistant Professor of Management
David A. Schrier, Assistant Professor of Management
ELECTRICAL ENGINEERING

The Department of Electrical Engineering and Computer Science administers a variety of degree programs, summarized in the table below. This department enjoys high national and international reputations based on the performance of its graduates in industry and in graduate studies, on the research achievements of its students and faculty, and on the textbooks written by its faculty. In 1983, a study by the National Academy of Science and Engineering, ranked the department's Ph.D. programs tenth among American universities offering electrical engineering doctoral programs, for both faculty quality and program effectiveness.

<table>
<thead>
<tr>
<th>Degree Programs Administered by the Department of Electrical Engineering and Computer Science</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNDERGRADUATE</strong></td>
</tr>
<tr>
<td><strong>Electrical Engineering</strong></td>
</tr>
<tr>
<td>Bachelor of Science</td>
</tr>
<tr>
<td>Options: Standard Program, Bioengineering, Computer Engineering, Electrophysics, Power Engineering</td>
</tr>
<tr>
<td><strong>Computer Science</strong></td>
</tr>
<tr>
<td>Bachelor of Science</td>
</tr>
<tr>
<td><strong>GRADUATE</strong></td>
</tr>
<tr>
<td><strong>Electrical Engineering</strong></td>
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<td>Master of Science, Electrical Engineer, Doctor of Philosophy</td>
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<tr>
<td><strong>Electrophysics</strong></td>
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<tr>
<td>Master of Science, Electrophysics, Doctor of Philosophy</td>
</tr>
<tr>
<td><strong>Computer Science</strong></td>
</tr>
<tr>
<td>Master of Science, Doctor of Philosophy</td>
</tr>
<tr>
<td><strong>System Engineering</strong></td>
</tr>
<tr>
<td>Master of Science, System Engineer, Doctor of Philosophy</td>
</tr>
<tr>
<td><strong>Information Systems</strong></td>
</tr>
<tr>
<td>Master of Science</td>
</tr>
</tbody>
</table>

This section of the catalog specifically describes the programs and courses in electrical engineering. Programs and courses in computer science and the graduate program in information systems are described in the computer science section of this catalog. The graduate programs in electrophysics and in system engineering are described in the appropriate catalog sections; however, the courses for these two programs (except for thesis) are located in this section.

The Electrical Engineering Profession — Electrical engineering is a rapidly growing profession which has evolved from its early beginnings in electrical power generation and distribution through the development of radio to television and computers. More recently, the profession has contributed to man's pleasure, safety and health with automatic systems and devices used daily in medical and health care, high-speed transportation and satellite communication.

While the undergraduate and graduate programs in electrical engineering are designed primarily to develop talents in the areas mentioned above, graduates eventually apply their training to such diversified fields as bioengineering, city planning, aeronautics, radio astronomy, system engineering, management and patent law. As students mature and realize their abilities, their professional lives may center on engineering, government, sales or education.

The electrical engineering faculty at Polytechnic covers a wide range of fields of specialization. Principal areas of teaching and research are micro-electronic devices and systems, computer engineering and computer science, telecommunications, signal and image processing, opto-electrics and opto-acoustics, microwave engineering, power systems and energy conversion, plasma science and engineering, system and control engineering, quantum electronics and material science.

**UNDERGRADUATE PROGRAM**

The program for the degree of bachelor of science in electrical engineering gives the student a broad-based preparation for a career in electrical engineering in any of its specializations and preparation for immediate employment in industry or government, or for further graduate education. The department offers a standard program, as well as four specialized options: computer engineering, power engineering, electrophysics and bioengineering. The first two years of all programs are essentially the same. In the standard program, upperclass students are able to sample several different areas through their choice of senior elective courses. The four options represent modified courses of study constructed for those juniors and seniors who desire to concentrate on some areas in greater detail.

All of Polytechnic's electrical engineering undergraduate programs, on the Brooklyn and Farmingdale campuses, day and evening, standard program as well as options, are accredited by the Accreditation Board for Engineering and Technology (ABET), on which the Institute of Electrical and Electronics Engineers (IEEE) is a participant.

**UNDERGRADUATE OPTIONS**

**Programs in Computers** — The programs in computers are designed to provide the student with a broad, basic preparation in the theory, organization and application of computers and information processing systems. The student interested in computers may choose either one of the following programs: (a) the computer engineering option, leading to the bachelor of science in electrical engineering or (b) the computer science program, leading to the bachelor of science in computer science (see page 88). Both programs draw from
the same core curriculum of computer courses and both require that the student take a balanced selection of software (programming languages, etc.) and hardware (computer architecture, minicomputer laboratory, etc.) courses; both programs also require the same mathematics, physics, and chemistry courses. The computer engineering option offers the engineering-oriented student the opportunity of obtaining the bachelor of science in electrical engineering while simultaneously acquiring a thorough grounding in the basics of computers. Beginning in the fifth semester, the computer engineering option contains a required sequence of integrated course offerings which covers such areas as switching circuits, computer organization, machine language programming and two laboratory courses with hands-on minicomputer and microcomputer experience. The program is completed in the senior year by an appropriate selection of computer or computer-related elective courses, including programming language translators, computer systems and an optional senior project.

**Power Engineering Option** — The power option is intended to provide the student with workable knowledge of the field in line with the needs of today's electric power industry. The intention is not to provide strong specialization, but rather to give focus to the student's interests. The knowledge acquired will enable the graduate to understand the physical reasons of why an electrical machine functions, and to analyze its external characteristics as a system unit. Other topics covered are transmission and distribution of electric power, design and analysis of fault prevention, and safety measures. The background thus acquired will give the student a head start in all branches of the electric power industry.

**Electrophysics Option** — The electrophysics option is intended for the electrical engineering student whose interests lie in the broad areas of electromagnetic and solid-state devices, as contrasted to circuits, systems, computers or power. A variety of senior elective courses cover the principles that underlie the hardware of electrical engineering and the influence of these principles on device design. This option prepares a student for work in such areas as antennas and microwave components, as found in radio and radar systems; lasers and optical components, as used in optical communications; and integrated circuits, parametric amplifiers, Gunn oscillators, etc., which are the elements used to generate and process electrical signals.

**Bioengineering Option** — The bioengineering option is intended for the electrical engineering student interested in combining a career in the life sciences with electrical engineering. The option includes all the requirements of the standard B.S. in electrical engineering program. The specialized courses in the option, taken in lieu of electrical engineering electives, give the student a background in biology, chemistry and physiology. The program enables the student to become an engineering member of medical and hospital teams, to work in areas such as prosthesis design, medical instrumentation, and medical data analysis, or to continue with graduate study in bioengineering.

**EVENING UNDERGRADUATE PROGRAM**

The bachelor of science in electrical engineering degree can also be earned in an evening program. The Polytechnic Institute of New York is unique among engineering colleges in that it offers identical programs and diplomas to full-time and part-time students. Day and evening sections of a course have identical content. Full-time and part-time students are likely to attend the same evening classes, and they are subject to the same academic standards. Transfer between full-time and part-time status is possible at any time.

Since the needs of evening students vary, a prescribed sequence of courses is not possible. Consequently each individual student should consult with the evening adviser in person or by telephone.

**TRANSFER STUDENTS**

Qualified graduates of two-year pre-engineering programs, such as those given at liberal arts colleges and community colleges, may fulfill the requirements for the B.S. in electrical engineering in two additional years. Since pre-engineering programs vary, a prescribed program is not possible; consequently, the student should consult with an undergraduate adviser.

Graduates of technology programs may be able to fulfill the requirements for the B.S. in electrical engineering in two to three-and-one-half years, depending on the scope and level of their previous education. Consult with an undergraduate adviser for details.

Transfer credits granted for graduates of programs at other schools are subject to frequent changes, based on evaluation of content and level. Thus students completing the same program, but in different years, may receive different amounts of transfer credit. Consult the electrical engineering undergraduate adviser for current information.

Transfer students must arrive and present their records for evaluation at least one week before the regular registration period for their first semester at Polytechnic.
## Curriculum of Study for the Bachelor of Science Degree in Electrical Engineering (For Freshmen entering in 1983)
### Standard Program

#### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
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<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I*</td>
<td>4</td>
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</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2 1/2</td>
<td>0</td>
</tr>
<tr>
<td>HU 101</td>
<td>College Composition*</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>SS 104</td>
<td>Contemporary History*</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education*</td>
<td>0</td>
<td>2</td>
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</tbody>
</table>
### BIOENGINEERING OPTION

Freshman and sophomore courses as in standard program.

<table>
<thead>
<tr>
<th>Junior Year</th>
<th>Senior Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 235</td>
<td>EE 195</td>
</tr>
<tr>
<td>EE 103</td>
<td>EE 167</td>
</tr>
<tr>
<td>EE 111</td>
<td>EE 161</td>
</tr>
<tr>
<td>EE 195</td>
<td>EE 113</td>
</tr>
</tbody>
</table>

### ELECTROPHYSICS OPTION

Freshman and sophomore courses as in standard program.

<table>
<thead>
<tr>
<th>Junior Year</th>
<th>Senior Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 236</td>
<td>EL 571</td>
</tr>
<tr>
<td>EE 103</td>
<td>EE 194</td>
</tr>
<tr>
<td>EE 111</td>
<td>EE 195</td>
</tr>
<tr>
<td>EE 195</td>
<td>EE 196</td>
</tr>
</tbody>
</table>

### POWER ENGINEERING OPTION

Freshman and sophomore courses as in standard program.

<table>
<thead>
<tr>
<th>Junior Year</th>
<th>Senior Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 236</td>
<td>EE 195</td>
</tr>
<tr>
<td>EE 103</td>
<td>EE 196</td>
</tr>
<tr>
<td>EE 111</td>
<td>EE 197</td>
</tr>
<tr>
<td>MA 223</td>
<td>200</td>
</tr>
</tbody>
</table>

Total credits required for graduation: 136
### COMPUTER ENGINEERING OPTION

#### Freshman Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Credits</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 111</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MA 101</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PH 101</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>CM 101</td>
<td>2½</td>
<td>0</td>
<td>2½</td>
</tr>
<tr>
<td>CM 111</td>
<td>0</td>
<td>1½</td>
<td>½</td>
</tr>
<tr>
<td>HU 101</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 101</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>CS 203</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MA 102</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PH 102</td>
<td>3½</td>
<td>1½</td>
<td>¾</td>
</tr>
<tr>
<td>CM 102</td>
<td>2½</td>
<td>0</td>
<td>2½</td>
</tr>
<tr>
<td>CM 112</td>
<td>0</td>
<td>1½</td>
<td>½</td>
</tr>
<tr>
<td>SS 104</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 102</td>
<td>0</td>
<td>2</td>
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</table>

17 credits total

#### Sophomore Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Credits</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>EE 101</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>EE 193</td>
<td>3</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CS 204</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MA 104</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PH 103</td>
<td>2½</td>
<td>1½</td>
<td>3</td>
</tr>
<tr>
<td>HU 200</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 103</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>EE 102</td>
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<tr>
<td>EE 194</td>
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<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MA 103</td>
<td>3</td>
<td>0</td>
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</tr>
<tr>
<td>PH 230</td>
<td>2</td>
<td>0</td>
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</tr>
<tr>
<td>AM 115</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>HU/Educ.</td>
<td>3</td>
<td>0</td>
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<tr>
<td>PE 104</td>
<td>0</td>
<td>2</td>
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</tbody>
</table>

16 credits total

#### Junior Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Credits</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 103</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>EE 111</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>EE 195</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>CS 205</td>
<td>3</td>
<td>0</td>
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</tr>
<tr>
<td>CS 236</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Hum./Soc.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Elective</td>
<td>3</td>
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</table>

18 credits total

#### Senior Year

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Credits</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 113</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>EE 161</td>
<td>4</td>
<td>0</td>
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</tr>
<tr>
<td>EE 188</td>
<td>1</td>
<td>3</td>
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</tr>
<tr>
<td>MA 223</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Technical</td>
<td>3</td>
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<td>3</td>
</tr>
<tr>
<td>Hum./Soc.</td>
<td>3</td>
<td>0</td>
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</tbody>
</table>

18 credits total

#### Total credits required for graduation: 136

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**Notes:**

- Newly admitted students take the English Composition Placement Test administered by the Department of Humanities and Communications. Most students are placed in HU 101 or HU 103. A few may be exempted from HU 101 and placed directly in HU 200, and others may first be required to take the non-credit HU 006 or HU 009.

- Full-time students take four semesters of Physical Education; the same PE course number may be repeated. Polytechnic ROTC courses MS 101, 102, 201, and 202 and Manhattan College ROTC courses AF 101, 102, 201, 202 may be substituted on a zero-credit basis.

- Physical Education is waived for students who attend part-time for their first 68 credits, and for students who receive 68 transfer credits. The waiver is provided when part-time attendance is less than 68 credits.

- CP 101-102 are required of full-time students in the Cooperative Education Program and must be completed before assignment to the first work period. These courses are not a B.S. degree requirement.

- IS 143-144 may be substituted for HU 200 plus SS 104.

- Take any HU, IS, ML, or SS lettered course, with adviser approval.

- Students with superior mathematical aptitude may replace the MA 101-MA 104 sequence by MA 111-MA 114. Consult the Department of Mathematics about your eligibility and course availability.

- AM 115 may be replaced by AM 116-117.

- Technical electives are chosen from a list of approved courses, departmental and out-of-department, published and updated each year. Concentration electives are chosen from a restricted list published for each curriculum option. You may propose alternative courses to the adviser. A free elective can be any course as long as the subject is not a duplicate of material studied under another course number.

- See footnote 2 for restriction on project courses.

- ROTC credits may be used at a maximum of six credits of junior/senior level courses to replace three credits of technical electives and three credits of free electives. The eligible courses are MS 301, 303, 401, 403 and Manhattan College AF 305, 307, 405, 406.

- Choose any two of the three courses, or one of the two, as listed:

- May be offered in alternate years. Consult adviser.

- EE 199 may be replaced by EE 296 or by EE 397. Not more than six credits of project courses, (EE 395, 396, 397, 398, CS 398) may be offered towards the B.S. (EE) degree.
Graduate courses (non-daggered) may be taken as electives by senior students whose junior year grade-point average in technical courses exceeds 2.7. Daguerrean electrical engineering graduate courses may be taken as senior electives by any undergraduate.

DEPARTMENTAL STANDARDS AND PROBATION—
To earn a degree in the Department of Electrical Engineering, students must earn a minimum C average (2.0 grade-point average) in all technical courses, mathematics, physics, computers and engineering.

Students are automatically placed on departmental probation if their semester or cumulative technical average is less than 2.0, if they receive C or less in any sophomore year electrical engineering course, or if they fail to adhere to course prerequisites. Students on probation must consult their advisers during the registration week prior to the beginning of each term. They may be required to repeat courses in which they have earned grades of C or less, or an incomplete, to postpone an advanced course, to take a special program of courses to improve their understanding or to withdraw from the department in cases of repeated departmental probation. Almost without exception, students earning a D+ or less in EE 101 or EE 102 will be required to repeat the course. Likewise, a student who earns an average of C- or less in technical courses during one semester, or in a closely related sequence of courses, will almost inevitably be required to repeat some of these courses.

Information—The Undergraduate Student Manual, issued to every student, contains further details on courses approved as electives, new courses, special announcements are posted on the bulletin boards outside of the undergraduate office in Brooklyn and the departmental office in Long Island. Each student is responsible for keeping informed.

GRADUATE STUDY

The Department of Electrical Engineering and Computer Science offers graduate programs leading to the degrees of master of science, engineer and doctor of philosophy in the areas listed in the table at the beginning of this section. The programs leading to degrees in electrical engineering are described in the following paragraphs. Other sections of this catalog describe the programs in electrophysics, system engineering and computer science.

The requirements for graduate degrees in electrical engineering are quite general. Each student may follow a program that specializes in any one of a variety of fields, including those described in the following paragraphs.

Outstanding students should apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

Computer Engineering—Computer engineering deals with the design, construction and utilization of digital computers. This includes the special circuits and devices that are used in computers and the mathematical theories for their description, including switching and automata theory. Appropriate courses include those listed below under electronics and information science, as well as those listed under computer science.

Information Science—Information science deals with the various communications systems, such as television, voice and data transmission, radar, telemetry and space communication, facsimile and display systems, plus the modern problems associated with data analysis and communication between man and machine and between machine and machine.

Systems and Control—Systems engineers are concerned with modeling and predicting the behavior of large systems from a knowledge of the component parts. Examples include air-traffic control systems, health-care delivery systems, systems to monitor and control pollution of the environment. Control engineers are concerned with all aspects of automatic regulation of system performance. Together with the system engineer, they are trained in the fields of automation and system theory. Typical examples of control systems are automatic guidance systems for aircraft and space vehicles, electric motor control and chemical process control.

Electronics and Networks—The discipline of electronics and networks involves the design, construction and theoretical treatment of circuits used in modern electronic equipment, particularly those involving semiconductor devices and integrated circuits.

Fields and Waves—Studies in fields and waves include electromagnetic and acoustic wave radiation and propagation under a variety of conditions, including nonlinear, anisotropic and periodic media. Such studies include microwave waveguides and antennas, optical fibers and integrated optics, diffraction and scattering effects, surface and bulk acoustic wave propagation and transduction. Applications include radar, microwave and optical communications, and surface acoustic wave technology.

Plasma and Atmospheric Physics—This area is involved with breakdown and ionization of gases and the interaction of the resultant plasma with electromagnetic waves. Such studies have application to thermonuclear power generation, understanding solar and planetary atmospheres, and propagation of radio waves in the ionosphere.

Power Systems and Energy Conversion—Studies in power and energy include not only the traditionally important generation, conversion and distribution of electrical power but also such modern topics as ion plasmas and fuel cells for the generation of electrical energy and the realization of ionic propulsion for space vehicles.
Quantum Electronics and Material Science —
Quantum electronics and material science deals with the interaction of electromagnetic fields and waves with matter, which can be understood only through a quantum theoretic treatment. Topics of interest include masers and lasers, nonlinear optics, quantum optics, holography, and electric, magnetic and thermal properties of material.

THE MASTER'S DEGREE

Admission to the master of science program requires a bachelor's degree in electrical engineering, from an accredited institution, with a superior undergraduate record.

Students not meeting all these requirements will be considered for admission on an individual basis, and may be admitted subject to the completion of appropriate undergraduate courses to remove deficiencies in preparation. A student who also desires to obtain a Polytechnic B.S. degree in electrical engineering must do so first, before beginning to study for a master's degree in the Department of Electrical Engineering and Computer Science.

Applicants lacking an electrical engineering bachelor's degree who are otherwise sufficiently prepared for admission without undergraduate deficiencies may nevertheless be required to take specified introductory level graduate electrical engineering courses. Such graduate courses will not count toward the master's degree. Students without an electrical engineering B.S. may also want to consider the departmental master's degree programs in electrophysics, and in system engineering.

Outstanding students should apply for financial aid in the form of research fellowship, teaching fellowship or partial tuition remission.

DEGREE REQUIREMENTS

To satisfy the requirements for the M.S. in electrical engineering degree, the student must complete a total of 36 units of courses, as described below, with an overall grade average of B. In addition, a B average is required in specific groups of courses, as indicated below.

1. Core Courses

   Three courses from the following:
   - EL 531 Probability
   - EL 610 Linear Systems
   - EL 611 Signals, Systems and Transforms
   - EL 641 Advanced Electronic Circuity
   - EL 671 Fields and Waves
   - CS 671 Switching and Automata

   9 units

2. Two one-year sequences which may include the courses in group (1). At least one of these one-year sequences must be in EL courses.

   6-12 units

3. Approved electives, which may include a thesis (9 units) and one reading course (3 units maximum):

   21-15 units

Total: 36 units

At least 18 of the 36 units offered for the M.S. in electrical engineering must be in EL prefixed courses.

An overall B average is required in the combination of five to seven courses offered to satisfy categories (1) and (2) in the above table.

The core courses cover fundamental material and should be taken as early in the program as possible.

A complete program of study, including the choice of one-year sequences, is arranged with a departmental adviser. The departmental Graduate Student Manual should first be consulted for detailed rules and procedures, such as student status, recommended one-year sequences, recommended electives, current areas of research, repetition of courses and disqualification for low grades. The manual also contains announcements of changes in degree requirements, if any, adopted by the faculty subsequent to the publication of this catalog.

Out-of-department courses (i.e., courses not carrying the departmental prefixes EL or CS). A maximum of 12 units of approved courses may be offered as electives.

Thesis: An exceptional student may elect to write a master's thesis for which 9 units toward the degree may be earned. Such a student should find an appropriate adviser who has agreed to monitor the thesis research. The research need not be original, but should adequately demonstrate the student's proficiency in the subject material. An oral defense of the master's thesis with at least three professors in attendance is required.

Transfer credits: The 9 units of transfer credits which may be allowed in accord with Institute regulations can be applied toward the one-year sequence requirements and toward the electives. Transfer credits may not be used to satisfy the core course requirements.

Validation credit: Validation credit may be allowed in accord with Institute regulations. In order to obtain credit, permission to take the validation examination must first be obtained by application to the EE Graduate Committee.

Repetition of courses: A student may register no more than three times for the same course including registration for which a W was earned. A course will not be allowed for degree credit if it was taken in violation of this rule.

Energy Program: Students in the Energy Program are required to offer a more specific list of courses within the following tabulation.

1. Core courses: EL 531, EL 610 or EL 611, EL 671.
2. One-year sequences: EL 661, EL 662, EL 663, EL 666.
3. Electives:
   (a) ES 927-928 is required
   (b) 9 units from a list of specified courses.

For full details, consult the catalog section for the Energy Program, page 000.
THE ENGINEER DEGREE

The engineer in electrical engineering degree is offered in recognition of the need of system and component designers for advanced training beyond the master's degree. This degree program involves additional graduate courses and a substantial design project.

A guidance committee, usually drawn from the full-time faculty of the department, advises the student and grants final approval when the department requirements have been satisfied. The guidance committee usually consists of three members; the chairman and at least one other member should be from the Department of Electrical Engineering and Computer Science. Participation is encouraged by a committee member (or members) from the adjunct faculty or from another department. The committee is appointed shortly after the student is admitted to the program.

The complete program for each student is detailed following consultation between the student and the guidance committee. The minimum requirements of the program are 72 units past the bachelor's degree apportioned as follows:

1. A master's degree in electrical engineering, for which the student receives 36 units
2. An engineer project that demonstrates mature design, engineering economics, trade-offs, etc., for which the student receives 6-12 units
3. Approved electives 30-24 units
   72 units

The engineer project may be suggested by either the student or guidance committee and is officially approved on the student's submission of an acceptable written proposal that details the problem, background and approach, gives a budget for estimated project expenses and states the desired number of units (6, 9 or 12) to be earned. On completion of the engineer project, the student will submit bound copies of the project report and will defend the work at an oral examination. More detailed information regarding the project and defense may be found in the Graduate Student Manual.

In certain exceptional cases involving students with well-documented records of original significant analysis and design achievements, the guidance committee may waive the requirement that the analysis and design work be performed in residence. However, bound reports and an oral defense will still be required. In such cases, six units of project will be credited toward the degree.

The student shall choose elective courses with the advice and consent of the guidance committee to achieve a concentrated and well-integrated background in the chosen area. Courses outside the electrical engineering area are generally acceptable provided they build toward the student's goal. Typical areas of concentration are power, safety and reliability, electronics, systems and controls, communications, computers and electro-optics.

THE DOCTOR'S DEGREE

General — Graduate students who have exhibited a high degree of scholastic proficiency and have given evidence of ability for conducting independent research may consider extending their goals toward the doctorate. The degree of Ph.D. is awarded after completing the program of study and research described below and on preparation and defense of a dissertation representing an original and significant contribution deemed worthy of publication in a recognized scientific or engineering journal.

Admission to Program — Entrance into doctoral program of study and research is contingent on the candidate's passing the departmental qualifying examination and forming a guidance committee (both described below). A student entering with a bachelor's degree will normally take the qualifying examinations after one year of study. Entering students holding a master's degree may take these examinations as soon as they are prepared, but are expected to submit to examination within the calendar year.

Students entering the doctoral program at the baccalaureate level must meet the above-listed entrance requirements for the master's program. Students entering at the master's level for the Ph.D. program in electrical engineering are normally expected to have a master's in electrical engineering.

Qualifying Examinations — The Ph.D. qualifying examinations are offered once each year, generally at the opening of the academic year in September. These examinations are divided into three sections: (a) basic section—a written examination requiring a broad coverage of knowledge and problem-solving ability at the undergraduate level; (b) advanced section—a written examination requiring preparation at the first-year graduate level in several subject areas related to the student's principal area of interest; (c) concentration section—an oral examination concentrating mainly on the student's declared area of interest. Principal areas of concentration are communications, computers, automatic control, electronics, electromagnetics, electro-optics and power. Students interested in the related areas of electrophysics and system engineering should refer to the corresponding Ph.D. programs described under those titles.

Details regarding allowed subject areas, recommended background courses, sample examination questions and the precise format for the coming year are available in the latest Graduate Student Manual.

Guidance Committee — On passing the qualifying examinations, the graduate student suggests a guidance committee composed of three members of the faculty, one selected from the student's major areas of interest, and the other two from the two minor areas. The member representing the major area is
named chairman of the committee and becomes the student's prospective thesis adviser. Information regarding selection of thesis topics and advisers is available in the electrical engineering graduate office. In the event a thesis adviser other than the chairman is agreed on, the adviser becomes a fourth member of the guidance committee. In consultation with the chairman and student, the committee members from the minor areas will approve the student's minor program. In addition, the guidance committee will approve the student's dissertation and conduct the thesis defense examination.

Course Requirements — Polytechnic requires that each candidate for the doctorate complete a minimum of 90 units of academic work beyond the bachelor's degree, including a minimum of 24 units of dissertation research. Ph.D. students are required to take a minimum of 12 units of courses in each of two minor areas. The minor must be taken in an area that is both distinct from and yet consonant with the student's major area of study. Approval of the minor program is described in the preceding paragraph. The major program of study is developed by the student in consultation with the chairman of the guidance committee. The major program should constitute a coherent study in depth of the most advanced knowledge in the student's chosen area of concentration. Attendance at graduate seminars is expected when they are offered in the student's principal area of interest (see course description EL 891).

Area Examination — The area examination is an oral examination administered by the guidance committee and is normally taken at the midpoint of the student's dissertation research program. The function of the examination is primarily to assess the depth of knowledge and understanding possessed by the student and secondarily to monitor the student's progress in the initial phase of the doctoral research program. The area examination is attended by the members of the guidance committee together with other appropriate faculty members who, because of their knowledge in the student's area of concentration, will assist in meeting the objective of the examination. An outline of the area defined for examination is prepared by the student and approved by the chairman of the guidance committee. Postponement of the examination beyond the midpoint (12 units) of EL 999 registration will require the approval of the doctoral adviser.

Submission of the Thesis and Final Examination — On completion of the doctoral dissertation, the candidate will submit to an oral defense of the thesis. The examination is conducted by the guidance committee but is open to all members of the faculty and to such other persons as may be invited. Copies of the dissertation will be made available to prospective examiners a reasonable time in advance. The guidance committee chairman will notify the Office of Graduate Affairs of the candidate's readiness so that the examination date may be scheduled. The student is advised to consult the Office of Graduate Affairs regarding submission of the final manuscript, reproduction and binding.
UNDERGRADUATE COURSES

Students are advised to consult the departmental Undergraduate Student Manual and the Registration Bulletin for changes in courses, course content and prerequisites in effect subsequent to the publication of this catalog.

General prerequisites: students may not register for any junior- or senior-level courses until every freshman requirement is completed. A knowledge of computer programming at the level of CS 111 is assumed in all EE courses.

BASIC COURSES

EE 101 Electrical Systems I 3:0:3
Passive and active circuit elements. Node and loop analysis, source transformations, linearity and superposition, voltage and current division Thevenin’s and Norton’s theorems. Source-free and forced responses of RL, RC and RLC circuits. CoPrerequisites: MA 104 and PH 103.

EE 102 Electrical Systems II 3:0:3

EE 103 Electrical Systems III 4:0:4

CONTROL AND INSTRUMENTATION

EE 104 Feedback System Principles 3:0:3

EE 107 Control System Design* 3:0:3

ELECTRONIC CIRCUIT ANALYSIS AND DESIGN

EE 111 Solid-State Devices and Circuits I 3:0:3

EE 112 Solid-State Devices and Circuits II 3:0:3

EE 113 Solid-State Devices and Circuits III 3:0:3
Voltage sweeps and function generators, multivibrators, comparators. Digital circuit and system applications including counters, shift registers, adders and memories. Sinusoidal oscillation and peak detection. Prerequisite: EE 112.

EE 114 Physical Electronics* 3:0:3
Introduction to study of physical electronics including motion of charged particles in presence of electric and magnetic fields. Space-charge limited devices, elements of semiconductor physics as applied to P-N junction theory, photo-diodes and solar cells, breakdown effects and transistor devices. Prerequisite: EE 111.

EE 115 Advanced Electronics 3:0:3
Special topics in electronic circuits and instrumentation, second-order modeling. Advanced transistor and integrated circuit design, active and passive memories. Application of bistable devices. Nonlinear devices including topics such as digital circuits, blocking oscillators, ferro-electric and ferro-magnetic circuits. Prerequisite: EE 113.

EE 116 Communication Electronics 3:0:3
Design and analysis of small signal and large signal tuned amplifiers, sin-wave oscillators, mixers, AM modulators and demodulators, FM modulators and demodulators. Prerequisite: EE 112.

EE 119 Semiconductor Technology* 3:0:3
Principal techniques involved in processing and fabrication of semiconductor devices and integrated circuits including material preparation, junction forming, circuit integration and packaging. Prerequisite: EE 111 or MT 410. Also listed under MT 375.

EL 545† Microwave Integrated and Semiconductor Circuits* See graduate course listings.

COMMUNICATIONS AND INFORMATION TRANSMISSION

EE 141 Signal Processing 3:0:3

EE 143 Computer Processing of Signals* 3:0:3
Processing of signals from speech, biomedical, seismic and traffic-flow measurements. Information extraction filtering, spectral analysis, model parameter estimation. Simulation of dynamic systems and signals. Pattern processing and recognition. Projects with small and large computers. Prerequisite: EE 141.

EL 533† Introduction to Communication Systems See graduate course listings.

ELECTROMAGNETIC FIELDS

EE 161 Transmission Lines and Waves 4:0:4
Transmission lines, acoustic and electromagnetic plane waves. Reflection and transmission at discontinuities, power and energy relations. Standing waves, impedance, reflection, transmission coefficients. Lossy transmission lines. Dispersion, group velocity. Spherical acoustic waves. Vectors, Maxwell’s equations in free space in integral form. Prerequisites: EE 102, PH 103, MA 103 and MA 104.
EE 152 Electromagnetic Fields 4:0:4

EL 571-572† Engineering Electromagnetics I, II
See graduate course listings.

EL 573† Introduction to Microwave Engineering
See graduate course listings.

ELECTRONIC MATERIALS SCIENCE

EE 157 Quantum and Solid State Electronics 3:0:3

EL 551-552† Electro-Optics I, II
See graduate course listings.

EL 557† Introduction to Electric and Magnetic Properties of Solids
See graduate course listings.

ELECTRIC POWER

EE 190 Electrical Machinery I 3:0:3
Description, theory and analysis of steady-state performance for the four types of electrical machine: transformer, induction motor, synchronous machine and DC machine. Equivalent circuits and vector diagrams derived and used as the primary tools for analysis. Prerequisite: EE 161.

EE 191 Electrical Machinery II 3:0:3
Two alternative unifying viewpoints of electrical machines are presented. One is based on physical considerations and leads to design guidelines. The second is based on Kron's theory and provides means for system analysis. Prerequisite: EE 160.

EE 193 Electric Power Systems 3:0:3
Principles of operating electric power systems. Transmission lines: inductance and capacitance parameters and current-voltage relations. Power system representation. Introduction to network calculations, symmetrical phase components, dynamic stability and economic dispatch. Prerequisite: EE 102.

EE 199 Electrical Machinery Laboratory
See course listing under electrical engineering laboratory. Co/Prerequisite: EE 181.

EL 564† Electromechanical Power Conversion
See graduate course listings.

EL 581† Introduction to Plasma Engineering
See graduate course listings.

ELECTRICAL ENGINEERING LABORATORY

Students enrolled in electrical engineering laboratory courses may be required to purchase a laboratory kit consisting of electronic parts and components. This is in addition to the indicated laboratory fees.

EE 188 Computer Laboratory I 2:3:3
A series of required experiments provides an introduction to small computers: digital and analog circuit techniques, small computer assembly language programming, minicomputer and microcomputer organization and operations. Lab fee required. Co/Prerequisite: CS 237.

EE 189 Computer Laboratory II 1:3:2
An introduction to the use of small computers as systems components: interrupt programming concepts, analog signal interfacing and real time, closed-loop systems. Independent learning and hands-on experience with different small computers are provided by projects involving such subjects as computer graphics, light intensity control and motor speed control. Lab fee required. Prerequisites: EE 188 and CS 237.

EE 193 Sophomore Electrical Engineering Laboratory I 0:3:1
Introduction to electrical measurements. Lab fee required. Co/Prerequisite: EE 101.

EE 194 Sophomore Electrical Engineering Laboratory II 0:3:1
Electrical circuits laboratory. Lab fee required. Prerequisite: EE 193 Co/Prerequisite: EE 102.

EE 195 Junior Electrical Engineering Laboratory I 1:3:2
Circuits and electronics laboratory. Lab fee required. Prerequisites: EE 194, EE 199 and Co/Prerequisite: EE 111.

EE 196 Junior Electrical Engineering Laboratory II 1:3:2
Experiments selected from various areas of electrical engineering. Lab fee required. Prerequisites: EE 196 and EE 199 and Co/Prerequisite: EE 112.

EE 197 Senior Electrical Engineering Laboratory I 1:3:2
Experiments selected from various areas of electrical engineering. Lab fee required. Prerequisites: EE 196 and EE 161 and Co/Prerequisite: EE 113.

EE 199 Senior Electrical Engineering Laboratory II 1:3:2
Experiments selected from various areas of electrical engineering. Special sections in electrical machinery, semiconductor technology, etc., may be offered. Lab fee required. Prerequisite: senior status. (Additional prerequisites may be specified for special sections.)

INTERDEPARTMENTAL COURSES

EE 370 Principles of Electrical Engineering 3:0:3
Electrical signals and circuit elements. Network analysis. Transient and sinusoidal steady-state analysis of first and second order circuits. Diode and transistor circuits. Digital and logic circuits. Cannot be used to satisfy any electrical engineering degree requirements. Prerequisite: PH 102 and Co/Prerequisite: MA 104.

EE 374 Instrumentation Laboratory 0:3:1
Experiments designed to supplement EE 370. Cannot be used to satisfy any electrical engineering degree requirements. Co/Prerequisite: EE 370.

PROJECTS AND SPECIAL LISTINGS

EE 391-394 Special Studies in Electrical Engineering* credit to be arranged
Advanced course in electrical engineering given to selected students. Course is vehicle for presenting novel material, trying new educational methods, taking advantage of special competences of visiting staff. Prerequisite: permission of electrical engineering adviser.
EE 395 EE Laboratory Project I 0:3:1
First phase of a project which requires the design, construction, testing, and documentation of a piece of equipment or of a software package, under the supervision of a faculty advisor. Definition of problem. Preparation of outline of procedure, equipment requirements, and cost estimate, summary report required. Prerequisite: senior status.

EE 396 EE Laboratory Project II 1:3:2
Second phase of project: design, construction, testing, and documentation of a piece of hardware or of a software package. Written final report must be filed in the department office for a passing grade. Lab fee required. Prerequisite: EE 395.

EE 397 Bachelor's Thesis in Electrical Engineering 3 credits
Individual solution of electrical engineering problem, involving adequate statement of problem, choice of method of attack, proper solution of problem. Presentation of results in formal bound report. Prerequisite: senior status and approval of head of undergraduate program.

EE 398 Project in Electrical Engineering credit to be arranged
Solution of electrical engineering problem or detailed study of advanced area of electrical engineering under supervision of advisor. Written report must be filed in the departmental office for a passing grade. Prerequisite: senior status.

GRADUATE COURSES

Graduate courses in electrical engineering are offered on each campus on a regular basis, annually or in two-year or three-year cycles. Consult the Graduate Student Manual for these scheduling cycles as well as for information about day offerings and about the summer program. The electrical engineering graduate mailing, sent out to continuing students prior to each registration, contains the latest information on selected topics course offerings, curriculum and course revisions.

Course number system: the courses below are grouped in terms of the middle digit which defines the academic level. The first digit represents the level:

5 — senior/graduate level
6 — first-year graduate level
7, 8 — advanced courses
9 — miscellaneous courses

Courses in selected topics bearing the same numbers may be repeated for credit provided the topics are different, subject to advisor's approval.

LINEAR SYSTEMS AND NETWORKS

EL 610 Linear Systems 2½:0:3

EL 611 Signals, Systems, and Transforms 2½:0:3

EL 613 Applied Matrix Theory 2½:0:3
In-depth introduction to theory and application of linear operators and matrices in finite-dimensional vector space. Invariant subspaces, elementary divisors, canonical forms and minimax theorems for eigenvalues of hermitean pencils. Prerequisites: MA 103 and MA 104. Also listed under MA 897.

EL 615 Network Theory of Lumped and Distributed Structures* 2½:0:3
Network principles derived from physical constraints are emphasized. Impedance and scattering formalisms, general energy and reciprocity theorems, properties of distributed parameter and non-geophysical networks, broad-band theory and the synthesis of transmission line broadband quasi wave transformers. Prerequisite: graduate status.

EL 617 System Reliability* 2½:0:3
Structural reliability, redundancy, bounds on reliability of complex systems: Repairable systems: Markov models, maintainability and availability. Optimization of spare parts inventories, inspection intervals and replacement times. Failure models: accumulated shocks and stress-strength-time. Marginal failure, dependent failure. Prerequisite: EL 531 or MA 561 or equivalent. Also listed under IE 685.

EL 618 Component Reliability* 2½:0:3
Failure models for industrial components: exponential, Weibull, lognormal, gamma, Gumbel and other distributions. Failure rates, hazard and reliability, reliability estimation and testing. Sampling plans based on life tests and accelerated life tests. Serial and parallel analysis on components reliability. Prerequisite: EL 531 or MA 561 or equivalent. Also listed under IE 686.

EL 611 Advanced Signals and Systems* 2½:0:3

EL 619 Advanced Control Theory 2½:0:3
Introduction to theory and application of linear operators and matrices in finite-dimensional vector space. Invariant subspaces, elementary divisors, canonical forms and minimax theorems for eigenvalues of hermitean pencils. Prerequisites: MA 103 and 104.

EL 621 Feedback Control I 2½:0:3
Analysis and synthesis of single-input-output, continuous time, control systems. Stability. Specifications for closed-loop sys-
tem performance methods. Introduction to optimization, integral-square-error compensation. Prerequisite: EE 104.


**EL 720 System Theory and Feedback** 2 1/2:0:3 Design of multivariable feedback systems in the complex s-plane. Stability of interconnected systems from component transfer matrices. The class of stabilizing controllers for the single-loop feedback system. Minimal controller realizations, observability and controllability. Prerequisites: EL 610 and EL 613.

**EL 723 System Optimization Methods** 2 1/2:0:3 Formulation of system optimization problems. Elements of functional analysis applied to system optimization. Local and global system optimization with and without constraints. Variational methods: calculus of variations, linear, nonlinear and dynamic programming. Iterative methods. Examples and applications. Prerequisites: EL 610 or EL 613.


**EL 823 Optimal Control Theory** 2 1/2:0:3 Optimal control problem for deterministic systems with variable constraints. Solution for both continuous and discrete-time systems using maximum principle and dynamic programming. Hamilton-Jacobi theory as applied to synthesis problem. Optimization problems with variable state constraints. Prerequisite: EL 723.

Also listed under MA 844

**EL 921-922 Selected Topics in Control Engineering I, II** each 2 1/2:0:3 Topics of current interest to feedback and control systems engineers. (See department catalog for detailed description of each particular offering.) Prerequisite: specified when offered.

**INFORMATION SCIENCE**

**EL 531 Probability** 2 1/2:0:3 Events, probability, repeated trials. Random variable, distributions, moments, characteristic functions. Functions of random variables. Sequence of random variables. Limit theorems. Engineering applications of statistics. Prerequisite: MA 223.

**EL 533 Introduction to Communication Systems** 2 1/2:0:3 Examples, principles and techniques for modern communications systems. Analog and digital signals, sampling, quantization, signal representation. Analog and digital modulation, pulse code modulation, time and frequency multiplexing. Noise in communication systems. Prerequisites: EE 103 and MA 223.

**EL 631 Engineering Applications of Stochastic Processes** 2 1/2:0:3 Correlation, power spectrum, coherence, with applications in linear systems. Nonstationary signals, normal processes, mean square estimation, spectral analysis. Topics in Markov processes. Prerequisite: EL 531.


**EL 635 Principles of Data Communication Networks** 2 1/2:0:3 An introductory course in data communications and computer communication networks. Many examples of networks, modeling. Basic principles of the design and performance analysis of networks. Data communication hardware: terminals, modems, multiplexers, concentrators; communications media; Nodal processor and host processor architecture. Software considerations and design protocols. Line control, polling and random access methods. Satellite and local area networks. Also listed under CS 535

**EL 733 Digital and Data Communications** 2 1/2:0:3 Concepts of M-ary communications, optimum receivers, signal design, block coding, achievement of channel capacity. Convolution coding and decoding, decoding algorithms. Transmission over band-limited channels; intersymbol interference, timed, adaptive and feedback equalization, concepts of modern design. Prerequisite: EL 533.


**EL 736 Computer Communication Networks II** 2 1/2:0:3 Principles of network design, network design algorithms, centralized network design, stable and dynamic routing algorithms, concentrator and switching node location, network reliability analysis, application of minimum spanning tree and shortest path algorithms to problems in network design, linear and integer programming techniques, distributed network design, case studies. Prerequisites: EL 735 and CS 603.

**EL 738 Algebraic Codes** 2 1/2:0:3 General theory of linear codes. Groups, rings, fields, matrices and vector spaces. Coding and error correction methods. Encoding and decoding cyclic codes. Convolutional codes and other encoding schemes. Capabilities and limitations of error-correcting codes. Emphasizes codes used in computers. Prerequisite: graduate status.

**EL 739 Information Theory** 2 1/2:0:3 Concepts of entropy and mutual information as mathematical measures for discrete information sources and discrete communication channels. Source encoding theorem and source coding techniques. Extension to sources with memory, channel capacity and noisy channel coding theorem. Extension to continuous waveforms. Prerequisite: EL 531.

EL 931-932 Selected Topics in Information Science I, II each 2½:0:3
Selected topics of current interest in information science. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.


digital devices, circuits and systems

EL 545† Microwave Integrated and Semiconductor Circuits† 2½:0:3
Semiconductor devices used in conjunction with transmission networks such as microstrip or slot line. S-parameter description of the equivalent transmission lines. Physical properties and equivalent circuit representation of semiconductor devices such as p-n junctions, varactors, Schottky barrier diodes, detectors, mixers, Gunn diodes, Impatt diodes, silicon bipolar and gallium arsenide FET's. Prerequisites: EE 162 and EE 112 or equivalent.

EL 641 Advanced Electronic Circuitry I 2½:0:3

EL 642 Advanced Electronic Circuitry II 2½:0:3

EL 643 Advanced Electronic Circuitry III 2½:0:3
Junction and field-effect transistors as switches. Basic digital and switching circuits. Integrated circuit logic schemes and "building blocks". Tuned and untuned power amplifiers. Sweep circuits and synchronization. Prerequisite: EL 641.

EL 644 Semiconductor Technology 2½:0:3

Also listed under MT 705

EL 645-646 VLSI System Design and Fabrication I, II each 2½:0:3
A two-semester course providing an overview of integration of digital functions onto single silicon chips using "Mead-Conway" design methods. The first semester concentrates on implementing a system design from circuit topology to patterning geometry to wafer fabrication. The culmination is a student design submitted for fabrication and testing. The second semester concentrates on the fabrication and testing techniques which are prevalent in the semiconductor industry and which are related to the design submitted during the first semester. EL 645 prerequisites: graduate status; CS 237 or CS 613; EE 112 or equivalent. EL 646 prerequisite: EL 645.

EL 647 Power Electronics 2½:0:3
Principles of thyristor devices, dynamic characteristics of DC choppers, dependence of turnoff circuits on load characteristics. Phase control, full wave circuits with inductive load, commutation. Power inverters. Prerequisite: graduate status.

EL 941-942 Selected Topics in Electronics I, II each 2½:0:3
Special topics of current interest to staff in the field of electronic devices, circuits and systems. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

electro-optics, quantum electronics and materials science

EL 551-552† Electro-Optics, I, II each 2½:0:3
Propagation of plane waves, polarization, reflection, refraction and diffraction of light. Interference: spatial and temporal coherence, the Michelson and Fabry-Perot interferometers and applications. Visible and infrared light sources, black-body radiation, radiation by atom, stimulated emission of radiation, coherent light sources. Dielectric materials, anisotropy and birefringence, electro-optic effects and applications. Image formation: holography, spatial signals, spatial Fourier transform, spatial filtering, optical information processing, optical communication, computer applications. EL 551 prerequisite: EE 162 or equivalent. EL 552 prerequisite: EL 551.

EL 557† Introduction to Electric and Magnetic Properties of Solids 2½:0:3
Crystal structure and dynamics, lattice vibrations, the phonon, thermal conductivity of solids. Energy-band theory. Brillouin zones, conductors, semiconductors, insulators, semiconductor junctions, junction devices, light-emitting diodes, detectors for visible and infrared. Prerequisite: EE 157.

EL 651 Statistical Mechanics I 2½:0:3

Also listed under PH 683

EL 652 Statistical Mechanics II 2½:0:3

Also listed under PH 654

EL 653-654 Quantum Electronics I, II each 2½:0:3

EL 655-666 Quantum Mechanics I, II each 2½:0:3

Also listed under PH 667-668

EL 658 Fiber Optic Communications* 2½:0:3
Preview of fiber optic communications, optical fibers, light
EL 950 Laboratory in Electronic Materials and Electro-Optics* 0:3:3
Selected experiments in electrical properties of materials; physical properties of semiconductors. Half effect measurements, photoelectricity, superconductivity, magneto-resistance, masers and lasers. Harmonic generation, frequency mixing and modulation in optics and quasi-optic region. Experiments of project type designed to prepare students for independent research in above areas. Lab fee required. Prerequisite: Graduate status.

EL 951-952 Selected Topics in Quantum Electronics, Material Science and Electro-Optics I, II* each 2:1/2:0:3
Topics of current interest dealing with interaction of matter with electromagnetic fields. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

POWER ENGINEERING

EL 564† Electromechanical Power Conversion* 2:1/2:0:3
Motion of elementary charged particles in electromagnetic fields. Transformation laws for the electromagnetic field intensities. Magnetoplasma dynamical equations. Power density relations and the design of the armature conductors in terms of power densities. Representation of fields in terms of traveling waves, synchronous and asynchronous interaction. Steady-state performance of synchronous converters. MHD power generation. Prerequisite: EE 162.

EL 651 Introduction to Power System Engineering* 2:1/2:0:3
Power system engineering analysis; three-phase circuit calculations, static stability limits, network representations and load-flow calculations. Reliability analysis: generation and transmission reliability. Generation costing and economic dispatch. Prerequisite: Graduate status.

EL 652 Introduction to Power System Planning* 2:1/2:0:3
Power system economics: revenue requirements, load duration and reserve requirements. Load forecasting—econometric methods. Optimal expansion planning and methodologies. Optimum generation mix and optimal network expansion. Decision analysis techniques. Prerequisite: EL 651 or equivalent.

EL 663 Electrical Transient in Power Systems* 2:1/2:0:3
Analysis of lumped-circuit, normal and abnormal transients in power equipment and systems. Short-circuit fault analysis and transient recovery of three-phase circuits. Analysis of traveling-wave surges on transmission lines, windings and on integrated systems. Computer modeling. Prerequisite: Graduate status.

EL 664 Relay Fault Protection* 2:1/2:0:3
Protective relay functions and classification. Electromechanical relay types, operating principles and basic characteristics. Communication channels for relaying. Current and voltage transformers, transducers. Protection of buses, transformers, generators, motors and other station equipment by the zone protection method. Distribution and transmission line relaying systems. Relay setting calculations. Primary and backup protection application and philosophy with applied relay engineering examples. Prerequisite: EL 665 or equivalent.

EL 665 Power System Stability I* 2:1/2:0:3
Introduction to the study of power systems dynamics; mathematical modeling of prime movers, power plants, synchronous machines, field exciters, transmission lines, relay loads and stabilizers. Prerequisite: EL 621.

EL 666 Power System Stability II* 2:1/2:0:3
Study of electrical machine and system dynamics, system governing and generation control, prime-mover, energy supply, system dynamics and control. Prerequisite: EL 665.

EL 687 Introduction to Thermonuclear Power* 2:1/2:0:3
Survey of problems associated with attaining controlled thermonuclear power. Fusion reactions, thermonuclear reaction rates, plasma physics, radiative losses from plasmas, methods of plasma containment, energy extraction from plasmas. Prerequisite: Graduate status. Also listed under NU 619.

EL 688 Electric Drives I: Characteristics and Control* 2:1/2:0:3
Transient conditions in electric drives. Load torques, moments of inertia, masses and forces translated to a rotating shaft. Acceleration and deceleration time. Consideration in selecting motor power rating. Motor heating (cooling) under different kinds of duty. Load diagram construction. Speed control of electric drives. Four quadrants operation of dc and ac drives with static converter supply. Worked examples effectively illustrate the application of the mathematical derivations. Prerequisite: EE 160 or equivalent.

EL 699 Electric Drives II: Design* 2:1/2:0:3

EL 671 Power Electronics
See course listings under electronic devices, circuits and systems.

EL 961-962 Selected Topics in Power I, II 2:1/2:0:3
Topics of current interest in electric power engineering. (See departmental mailing for detailed description of each particular offering.) Prerequisite: to be specified when offered.

FIELDS AND WAVES

EL 571-572† Engineering Electromagnetics I, II each 2:1/2:0:3
Engineering applications of electromagnetics. A device/hardware oriented course for both graduate and advanced undergraduate students. Topics include: hollow conducting waveguides, dielectric guides, two-wire, coaxial and strip transmission lines, linear antennas, arrays, horn and dish antennas. Waveguide components: attenuators, phase shifters, waveguide-coaxial transitions, etc. Electromechanical transducers: loud speakers, microphones, relays, etc. EL 571 prerequisite: EE 162. EL 572 prerequisite: EL 571.

EL 573† Introduction to Microwave Engineering* 2:1/2:0:3
Review of transmission line theory and its relation to waveguides. Transverse resonance procedure for propagation characteristics. Waveguide discontinuities: alternative representations; equivalent circuits for various structures with examples in rectangular waveguide, microstrip and free space. Network methods for waveguides of composite or complex cross section, for waveguide attenuation and for resonant cavity Q. Introduction to leaky waves and to periodic structures. Prerequisite: EL 162 or equivalent.
EL 671 Fields and Waves 2%:0:3
Basic concepts of electric and magnetic fields; their sources and their propagation via waves are treated. Emphasis is placed on understanding electromagnetic wave phenomena (interference, reflection, refraction, etc.) and their engineering applications over the entire electromagnetic spectrum. Prerequisite: Graduate status.

EL 672 Electrodynamics: Wave Propagation and Guidance 2%:0:3
Course for students requiring understanding of electromagnetic fields from engineering point of view. Physical concepts, systematic mathematical methods and engineering interpretation of results equally emphasized. Excitation and propagation in metallic and dielectric guiding structures, discontinuities, resonators, radiation from antennas. Prerequisite: EL 671.

EL 673 Electrodynamics: Fields and Materials 2%:0:3
Interaction of electromagnetic fields with material media from classical viewpoint. Macroscopic description of dielectric, magnetic and conducting materials; energy relations, dispersion, and attenuation in dielectrics and ionized media. Wave propagation in anisotropic crystals and fornicis, waves in inhomogeneous media. Prerequisite: EL 671 or PH 623. Also listed under PH 624.

EL 674 Waves in the Atmosphere 2%:0:3
Static and dynamic conditions in the atmosphere. Wave types, theory of gravity waves and examples, effects of wind. Theory of tidal waves, dynamic effect, planetary and Rossby waves. Wave ducting, waves in the ionosphere. Turbulence in the atmosphere. Prerequisite: Graduate status.

EL 675 Fundamentals of Radar* 2%:0:3
Principles of range and direction finding by means of radar echoes. Requirements and limitations of radar, the radar equation and statistical nature of reception. Establishment of design criteria for radar receivers, indicators, modulators and microwave components. Presentation of systems and techniques including MTI, Doppler radars and pulse compression. Prerequisite: EL 671.

EL 771-772 Radiation and Diffraction I, II* each 2%:0:3

EL 773-774 Guided Waves and Beams I, II* 2%:0:3
Engineering applications of guided waves and beams in areas of electromagnetics (radar), microwave acoustics and integrated optics. Propagation characteristics of surface and leaky waves, effects of loss, mode coupling, characterization of discontinuities. Propagation in periodic structures. Beam fields, divergence, Fresnel and Fraunhofer approximations, scattering and guiding of beams by planar structures, beam displacement and distortion, coupling to surface waves. EL 773 prerequisite: EL 672. EL 774 prerequisite: EL 773.

EL 775 Antenna Theory* 2%:0:3

EL 777 Advanced Antenna Theory* 2%:0:3

EL 777-778 Ultrasonics I, II* each 2%:0:3

EL 871 Advanced Ray Methods in Wave Propagation* 2%:0:3
Asymptotic theory of radiation and diffraction, with emphasis on inhomogeneous and dispersive media. WKBJ approximations and comparison methods, advanced saddle-point techniques and relation to ray optics. Space-time rays in inhomogeneous dispersive media, diffraction and transition phenomena for transients. Prerequisite: EL 772.

EL 873 Nonlinear Waves* 2%:0:3

EL 971-972 Selected Topics in Electromagnetic Theory I, II* 2%:0:3
Aspects of electromagnetic and acoustic wave propagation, diffraction and radiation that are of current interest, including wave interactions with materials and special mathematical and numerical techniques. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

PLASMA SCIENCE AND ENGINEERING

EL 561† Introduction to Plasma Engineering 2%:0:3
Basic plasma concepts, collisional phenomena, elastic collisions, excitation, ionization, attachment, recombination, DC and AC breakdown and discharges, diffusion and mobilities, propagation of electromagnetic waves in plasma. Prerequisite: EE 162.

EL 781-782 Wave Turbulence I, II* each 2%:0:3
Analysis of homogeneous and nonstationary turbulent fields. Kinetic and fluid dynamic descriptions of many-particle systems at both quasilinear and nonlinear levels. Wave-particle and wave-wave instabilities treated as collision processes both classically and quantum theoretically. Determination of self-consistent kinetic equations for both particles and waves. Applications to space-time evolution of coupled background and turbulent wave fields. EL 781 prerequisite: Graduate status. EL 782 prerequisite: EL 781. Also listed under AM 753-754.

EL 783-784 Linear Wave Process in Plasmas I, II* each 2%:0:3
Oscillatory and guided wave representation of fields in general linear systems. Self-consistent nonequilibrium field description.
of particle and wave dynamics in classical plasma-like systems. Kinetic versus fluid dynamic description of gaseous and solid-state plasmas. Dispersion relations, wave structure and instabilities in isotropic and anisotropic plasmas. EL 783 prerequisite: EL 581. EL 784 prerequisite: EL 783.

DEPARTMENTAL PROJECTS, READINGS, THESIS AND SEMINARS

EL 891 Graduate Seminar* 2½:0:3
Seminar in various areas of electrical engineering, electromagnetics, system engineering and science, and computer science. Reports and discussions by staff members and students concerning recent developments in relevant areas. May be repeated for credit. Prerequisite: graduate status.

EL 990-991 Laboratory Internship I, II* each 0:5:3
Work in graduate laboratories under immediate guidance of faculty member. May be used as adjunct to or continuation of departmental graduate laboratory courses. Lab fee required. Prerequisite: degree status.

EL 993-994 Readings in Electrical Engineering I, II 2½:0:3
Designed primarily for students who desire to push toward frontiers of their specializations in electrical engineering, electromagnetics or system engineering and who have completed essentially all related course offerings. Readings conducted under guidance of faculty member who is expert in the field, consisting in general of readings in advanced literature. Examination required. Not more than 3 units may be offered toward the master's degree. Prerequisite: degree status.

EL 995-996 Advanced Projects I, II each 0:5:3
Theoretical and experimental projects in various research areas in electrical engineering and electromagnetics for advanced graduate students. Projects assigned on basis of specialized interest and preparation of student. Prerequisite: degree status.

EL 997 Thesis for Degree of Master of Science in Electrical Engineering each 3 units
Independent engineering project demonstrating professional maturity, performed under guidance of adviser. Oral thesis defense and written thesis volume required. Registration of 9 units required (continuous thesis registration required). Prerequisite: degree candidacy.

EL 998 Project for Engineer Degree in Electrical Engineering each 3 units
Comprehensive planning and design of electrical engineering project under guidance of faculty advisor. Examination on up-to-date techniques. Oral examination and written project report required. Scope of project is 0-6 units by prior agreement with adviser (continuous project registration required). Prerequisite: degree candidacy.

EL 999 Dissertation for Degree of Doctor of Philosophy in Electrical Engineering each 3 units
Original investigation of electrical engineering problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized journals. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: degree candidacy and passing qualifying examination. Registration beyond 24th unit requires passing of area examination.

FACULTY

Leonard G. Shaw, Professor of Electrical Engineering and Head of Electrical Engineering and Computer Science
B.S., University of Pennsylvania, M.S., Ph.D., Stanford University
Stochastic control, reliability

Joseph J. Bongiorno, Jr., Professor of Electrical Engineering and Assistant Department Head, Long Island Center
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Control Systems

Martin L. Shooman, Professor of Electrical Engineering and Computer Science, and Director of Computer Science
S.B., S.M., Massachusetts Institute of Technology; D.E.E., Polytechnic Institute of Brooklyn
Software engineering, system reliability and safety

Leonard Bergstein, Professor of Electro-Optical Sciences
Ph.D., Polytechnic Institute of Brooklyn
Electro-optics

Henry L. Bertoni, Professor of Electrophysics
B.S., Northwestern University; M.S., Ph.D., Polytechnic Institute of Brooklyn
Electromagnetics, acoustics

Robert R. Boorstyn, Professor of Electrical Engineering and Computer Science
B.E.E., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn
Computer communications networks, telecommunications

Edward S. Cassedy, Professor of Electrical Engineering
B.S., Union College; S.M., Harvard University; Dr.Eng., The Johns Hopkins University
Power, energy policies, plasmas

Bernard R.-S. Chea, Professor of Electrical Engineering
B.S., Taiwan College of Engineering (Taiwan); M.S., University of Notre Dame; Ph.D., University of California (Berkeley)
Electromagnetics, plasmas, power

Rudolf F. Drenick, Professor of System Engineering
Ph.D., University of Vienna (Austria)
System theory

Leopold B. Felsen, Institute Professor
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Propagation and diffraction, optics

Anthony B. Giordano, Professor of Electrical Engineering and Dean for External Affairs
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Electromagnetics, network theory, microwave networks
Stanley H. Gross, Professor of Electrophysics
B.S., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn
Ionospheric plasmas and atmospheric physics

Alexander Hessel, Professor of Electrophysics
M.Sc., Hebrew University; D.E.E., Polytechnic Institute of Brooklyn
Antenna theory

Donald F. Hunt, Professor of Electrical Engineering
B.S., University of Pennsylvania
Networks and systems

Frank Kozin, Professor of System Engineering
B.S., M.S., Ph.D., Illinois Institute of Technology
Stochastic systems

Ludwik Kurz, Professor of Electrical Engineering
Communications, pattern recognition, and image processing

Arthur E. Laemmel, Professor of Electrical Engineering and Computer Science
B.E.E., Polytechnic Institute of Brooklyn
Coding and computer circuits

James T. LaTourrette, Professor of Electrical Engineering and Computer Science
B.S., California Institute of Technology; A.M.
Ph.D., Harvard University
Quantum electronics, computer software

Enrico Levi, Professor of Electrophysics
B.S. (M.E.), B.S. (E.E.), Dipl. Ing., Technion (Israel),
M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Energy conversion

Frank J. Lupo, Professor of Electrical Engineering
B.E.E., M.E.E., New York University; Ph.D., Columbia University, P.E. (N.J.)
Bioengineering, networks, and systems

Nathan Marcuvitz, Institute Professor
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Nonlinear and turbulent waves

Eli Absalom Mishkin, Professor of Applied Physics
Ingenieur, Sc.D., Technion (Israel)
Quantum and nonlinear optics, laser-induced fusion

Arthur A. Oliner, Professor of Electrophysics
B.A., Brooklyn College, Ph.D., Cornell University
Electromagnetics, microwaves, integrated optics, acoustics

Istvan Palcz, Professor of Electrical Engineering and Electrophysics
Dip. E.E., Docent, University of Technical Sciences (Budapest, Hungary); Ph.D., Polytechnic Institute of Brooklyn
Wave propagation

Athanasios Papoulis, Professor of Electrical Engineering
M.E., E.E., Athens Polytechnic Institute (Greece); M.S., M.A., Ph.D., University of Pennsylvania
Signal theory

Myron M. Rosenthal, Industry Professor
B.S., CCNY; M.S., Adelphi University, P.E. (N.J.)
Radar, microwave techniques, EMI techniques

Philip E. Sarachik, Professor of Electrical Engineering
A.B., B.S., M.S., Ph.D. Columbia University
Optimal and adaptive systems

Harry Schachter, Professor of Electrical Engineering
B.E.E., CCNY; M.S., Columbia University, Ph.D., Polytechnic Institute of Brooklyn
Microwave acoustics and communication systems

Benjamin Senitzky, Professor of Electrophysics
B.E., Ph.D., Columbia University
Optical and semiconductor devices

Sidney S. Shamis, Professor of Electrical Engineering and Associate Provost
B.E.E., Cooper Union; M.S., Stevens Institute of Technology
Active network

Jerry Shmoys, Professor of Electrical Engineering
B.E.E., Cooper Union, Ph.D., New York University
Antennas, propagation

Edward J. Smith, Professor of Electrical Engineering
B.E.E., Cooper Union; M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Computer organization

Joel B. Snyder, Industry Professor
B.E.E., M.E.E., Polytechnic Institute of Brooklyn, P.E. (N.Y.)
Microprocessor systems, data acquisition and transmission, signal processing

Leonard Strauss, Professor of Electrical Engineering
B.E.E., CCNY; M.S., Columbia University
Integrated circuits

Theodor Tamir, Professor of Electrical Engineering and Electrophysics
B.S., Dipl. Ing., M.S., Technion (Israel); Ph.D., Polytechnic Institute of Brooklyn
Electromagnetics, electro-optics

Wen-Chung Wang, Professor of Electrical Engineering and Electrophysics
B.S., Taiwan Engineering College (Taiwan); M.S., Ph.D., Northwestern University
Microwave acoustics

Dante C. Youla, Professor of Electrical Engineering
B.E.E., CCNY; M.S., New York University
Networks, control systems
Frank A. Cassara, Associate Professor of Electrical Engineering  
B.S., Rutgers-The State University; M.S., Ph.D., Polytechnic Institute of Brooklyn  
Electronic circuits, communication systems

Douglas A. Davids, Associate Professor of Electrophysics  
B.S., M.S., Newark College of Engineering; Ph.D., The Johns Hopkins University  
Microwave acoustics, quantum electronics

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B.A., Brooklyn College; M.E.E., Polytechnic Institute of Brooklyn  
Microwave techniques

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Digital filters, power systems

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Computer architecture, microprocessor systems

Aaron Kershenbaum, Associate Professor of Computer Science  
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Computer communications, algorithms

Szu-Ping Kuo, Associate Professor of Electrophysics  
B.S., M.S., National Chiao-Tung University, (Taiwan); Ph.D., Polytechnic Institute of New York  
Magnetohydrodynamics

Maurice C. Newstein, Associate Professor of Electrophysics  
A.B., Temple University; Ph.D., Massachusetts Institute of Technology  
Quantum electronics

Saul W. Rosenthal, Associate Professor of Electrophysics  
B.E.E., M.E.E., Polytechnic Institute of Brooklyn  
Microwave techniques, bioengineering

Henry Ruston, Associate Professor of Electrical Engineering and Computer Science  
B.S.E. (Math.) B.S.E. (E.E.), Ph.D., University of Michigan; M.S., Columbia University  
Software engineering, programming, circuit theory

Leo M. Silber, Associate Professor of Electrophysics  
B.S., University of Massachusetts; M.S., Ph.D., Purdue University  
Magnetic materials, plasmas

William T. Walter, Research Associate Professor of Electrophysics  
A.B., Middlebury College; Ph.D., Massachusetts Institute of Technology  
Quantum electronics, atomic physics, wave-matter interaction

Gerald Weiss, Associate Professor of Electrical Engineering  
B.E.E., Cooper Union; S.M., Harvard University; D.E.E., Polytechnic Institute of Brooklyn; P.E. (N.Y.)  
Feedback theory, control instrumentation

Zivan Zabar, Associate Professor of Electrical Engineering  
B.Sc., M.Sc., Sc.D., Technion (Israel)  
Power electronics, energy conversion

Aziz Akmese, Visiting Assistant Professor of Electrical Engineering  
B.S., M.S., Black Sea Technical University (Turkey); M.S., Ph.D., Polytechnic Institute of New York  
Data communications, integrated circuits

Leo Birenbaum, Research Associate Professor of Electrical Engineering and Electrophysics  
B.E.E., Cooper Union; M.E.E., M.S., Polytechnic Institute of Brooklyn  
Bioeffects of microwaves, microwave measurements, electrical machinery

Christodoulos Chamzas, Assistant Professor of Electrical Engineering  
Diploma in EE-ME, National Technical University of Athens (Greece); M.S., Ph.D., Polytechnic Institute of New York  
Digital signal processing

Aladin H. Kamel, Assistant Professor of Electrophysics  
B.E.E., B.Sc., Ain Shams University (Cairo); Ph.D., Polytechnic Institute of New York  
Wave propagation and diffraction

Basil S. Maglaris, Assistant Professor of Electrical Engineering and Computer Science  
Dipl. EE, National Technical University of Athens (Greece); M.S., Polytechnic Institute of New York; Ph.D., Columbia University  
Computer communication networks, performance evaluation of computer systems

Shinzo Onishi, Research Assistant Professor of Electrophysics  
B.S., M.S., Ph.D., Electronics Engineering Kyoto University (Japan)  
Microwave circuits, electronic materials science
ADJUNCT FACULTY

Willard G. Bouricius, Adjunct Professor
B.A., Hastings College; M.S., University of Wisconsin; Ph.D., Yale University

Bernard Friedland, Adjunct Professor
A.B., B.S., M.S., Ph.D., Columbia University

Richard Gran, Adjunct Professor
B.E.E., M.E.E. Ph.D., Polytechnic Institute of Brooklyn

Rudolf G.E. Hutter, Adjunct Professor
State Exam, University of Berlin (Germany); Ph.D., Stanford University

George Karady, Adjunct Professor
Dipl. Eng., Ph.D., Technical University of Budapest (Hungary)

Ralph Gittleman, Adjunct Associate Professor
B.S., Massachusetts Institute of Technology; M.E.E., Polytechnic Institute of Brooklyn

Kenneth S. Schneider, Adjunct Associate Professor
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Frederick W. Scholl, Adjunct Associate Professor
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Theodore Andrikos, Lecturer
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Aly Elrefaie, Lecturer
B.S., Ain Shams University (Cairo); M.S.E.E., Polytechnic Institute of New York

Frank Gruppuso, Lecturer
M.S.E.E., Polytechnic Institute of New York

Howard Hausman, Lecturer
B.S., M.S., Polytechnic Institute of Brooklyn

Erh-Wen Hu, Lecturer
B.S., Cheng Kung University (Taiwan); M.S., University of Cincinnati; M.S., SUNY (Stony Brook); Ph.D., Polytechnic Institute of New York

Lee Jacknow, Lecturer
B.A., B.E., M.S., New York University

Alfred Jorysz, Lecturer
M.Sc., Institute of Technology (Vienna, Austria)

William Leacy, Lecturer
B.S.E.E., M.S.E.E., Polytechnic Institute of New York

Peter Oden, Lecturer
B.S., M.S., Ph.D., Columbia University

Mathas Paloszy, Lecturer
B.S., M.S. Josef Nadai's Technical University

O. James Pfeifer, Lecturer
B.S., Polytechnic Institute of Brooklyn; M.S., SUNY (Stony Brook)

Sheldon J. Rosenberg, Lecturer
B.E.E., M.S., New York University

Prodip Sen, Lecturer
Ph.D., Indian Institute of Science, Bangalore

Walter Vasilaky, Lecturer
B.A., Rutgers University; M.A., University of Maryland; Ph.D., Courant Institute; Ph.D., New York University

Peter Voltz, Lecturer
B.S., M.S.E.E., Polytechnic Institute of New York

Stephen B. Weinstein, Adjunct Professor
B.S., Massachusetts Institute of Technology; M.S., University of Michigan; Ph.D., University of California

Rainer Weschke, Lecturer
B.S., M.S., Polytechnic Institute of Brooklyn

EMERITUS FACULTY

Frank E. Canavaciol, Professor Emeritus
E.E., Polytechnic Institute of Brooklyn; D.Eng. (hon.), Polytechnic Institute of New York

William A. Lynch, Professor Emeritus
M.E., M.E.E., Polytechnic Institute of Brooklyn

Ernst Weber, Professor Emeritus and President Emeritus
Dr. Phil., University of Vienna (Austria); Dr. Techn., Technical University of Vienna (Austria)
ELECTROPHYSICS

Polytechnic offers a program of study leading to the degrees of master of science and doctor of philosophy in electrophysics. The program is intended to prepare students to work at the interface between electrical engineering and physics, where new engineering applications of various physical phenomena are developed. Emphasis is placed on wave propagation and wave interactions with matter, as applied to a wide range of topics. Students entering the program typically have an undergraduate background in electrical engineering or in physics, a strong interest in physical phenomena and/or applied mathematics, and a desire to participate in research. The program is administered by the Department of Electrical Engineering and Computer Science.

The program of study consists of basic courses in wave propagation, electromagnetic theory and mathematical techniques offered through the Department of Electrical Engineering and Computer Science. In addition, a variety of more specialized courses at both the master's and doctor's levels are offered, covering technical areas where there is research and development activity on a world-wide basis. Traditional areas of active research that are covered include propagation and diffraction of waves, antennas, microwave networks, plasmas and solid-state devices. Areas of modern optics that are covered include quantum electronics, lasers and optical communications. Additional areas are nonlinear wave propagation, ultrasonic waves in solids, planetary atmospheres and waves in the earth's atmosphere. The basic courses are offered yearly on both the Brooklyn and Long Island campuses. Specialized courses may be offered on one or the other campus, or in alternate years on the two campuses.

The electrophysics faculty at Polytechnic has made significant contributions to each of the areas cited above and maintains active theoretical and experimental programs in them. Because the electrophysics program is an outgrowth of these research activities, students in the program are exposed to the most current technical developments in each area and can be guided in research at the forefront of the areas. The theoretical effort is supported by extensive computational facilities existing at Polytechnic. The experimental research is carried out in laboratories in Long Island and Brooklyn. At Long Island, experimental facilities include a 500-foot antenna range, a microwave anechoic chamber, an ionospheric sounder, laser laboratories, an ultrasonics laboratory devoted to microwave acoustics, a solid-state and millimeter wave device laboratory and plasma laboratories. The Brooklyn campus has laboratories devoted to modern optics, ultrasonics, magnetic materials and thin films. The thin-film laboratory has extensive facilities for vacuum deposition and integrated circuit fabrication, and a scanning electron microscope.

REQUIREMENTS FOR THE MASTER'S DEGREE

The entrance requirements for the master of science in electrophysics are a bachelor's degree in engineering or science from an accredited institution, with a superior undergraduate record, including undergraduate courses in differential equations, electromagnetic theory, quantum and solid-state physics, and linear systems. Students with deficiencies in these areas may be admitted if they take appropriate introductory courses to remove these deficiencies. Outstanding students are advised to apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

To satisfy the requirements for the M.S. in electrophysics degree, the student must complete a total of 36 units of courses, as described below, with an overall grade average of B. In addition, a B average is required in specific groups of courses, as indicated below.

1. Three courses from among the following:
   - EL 551 Electro-Optics I
   - EL 561 Introduction to Plasma Engineering
   - EL 611 Signals, Systems and Transforms
   - EL 651 Statistical Mechanics I
   - EL 653 Quantum Electronics I
   - EL 671 Fields and Waves
   
   9 units

2. Two one-year sequences, which may include the above courses. At least one of these one-year sequences must be in EL courses.

   6-12 units

3. Approved electives

   21-15 units

   Total: 36 units

A complete course of study, including the choice of the one-year sequences, should be arranged in consultation with an adviser. A master's thesis of 9 units may be included as part of the elective courses. At least 24 of the 36 units must be in courses with EL, EP or CS prefixes, and 18 units of these must be in EL prefixed courses.

An overall B average is required in the combination of five to seven courses offered to satisfy categories (1) and (2) in the above table.

The departmental Graduate Student Manual should be consulted for more detailed rules and procedures, including student status, recommended electives and one-year sequences, current areas of research and disqualification for low grades.
REQUIREMENTS FOR THE DOCTOR'S DEGREE

Graduate students who have demonstrated a high degree of scholastic proficiency and have given evidence of ability for conducting independent research may consider extending their studies toward the doctorate.

Admission to Program—Admission to the program is based on qualifying examinations which a student usually takes after having completed one year of graduate studies. Successful completion of the master's requirements in electrophysics should provide adequate course preparation for the examinations.

Specific requirements for this degree parallel those for the Ph.D. in E.E. as described elsewhere in this catalog and in the departmental Graduate Student Manual. These include course requirements, guidance committee formation, area examination, submission of the bound thesis, etc.

Outstanding students are advised to apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

Qualifying Examinations—The format for the qualifying examinations is described in connection with the Ph.D. in electrical engineering. Principal areas of concentration for electrophysics candidates are: quantum and statistical mechanics, quantum electronics, electronics, electromagnetics and electro-optics. Current information about examination topics should be obtained from the doctoral adviser.

GRADUATE COURSES

EP 997 Thesis for Degree of Master of Science in Electrophysics each 3 units
Independent research project demonstrating professional maturity, performed under guidance of adviser. Oral thesis defense and formal, bound thesis volume required. Registration of 9 units required (continuous thesis registration required). Prerequisite: degree candidacy.

EP 999 Dissertation for Degree of Doctor of Philosophy in Electrophysics each 3 units
Original investigation of electrophysics problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: degree candidacy and passing of qualifying examination. Registration beyond twelfth unit requires passing of area examination.

PARTICIPATING FACULTY

Leonard Bergstein, Professor of Electro-Optical Sciences

Henry L. Bertoni, Professor of Electrophysics

Edward S. Cassedy, Professor of Electrical Engineering

Bernard R-S Cheo, Professor of Electrical Engineering
Leopold B. Felsen, Institute Professor
Stanley H. Gross, Professor of Electrophysics
Alexander Hassel, Professor of Electrophysics
James T. LaTourette, Professor of Electrophysics
Enrico Levi, Professor of Electrophysics
Nathan Marcuvitz, Institute Professor
Eli Absalom Mishkin, Professor of Applied Physics
Arthur A. Oliner, Professor of Electrophysics
István Palóczi, Professor of Electrical Engineering and Electrophysics
Harry Schachter, Professor of Electrical Engineering
Benjamin Senitzky, Professor of Electrophysics
Jerry Shmoys, Professor of Electrical Engineering
Theodor Tamir, Professor of Electrical Engineering and Electrophysics
Wen-Chung Wang, Professor of Electrical Engineering and Electrophysics
Leo Birenbaum, Research Associate Professor of Electrical Engineering and Electrophysics
Douglas A. Davids, Associate Professor of Electrophysics
Herman Farber, Associate Professor of Electrophysics
Szu-Ping Kuo, Associate Professor of Electrical Engineering and Electrophysics
Maurice C. Newstein, Associate Professor of Electrophysics
Saul W. Rosenthal, Associate Professor of Electrophysics
Leo M. Silber, Associate Professor of Electrophysics
William T. Walter, Research Associate Professor of Electrophysics
Shinzo Onishi, Research Assistant Professor of Electrophysics

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ENERGY PROGRAM

The energy program is an interdepartmental effort administered by the Division of Engineering. Recognizing the multifaceted, interdisciplinary nature of energy problems and studies, the program integrates human and physical resources at Polytechnic to provide cohesive curricula, research and service activities in technological, economic, managerial, social, political and humanistic areas. Thus Polytechnic resources are applied to the solution of global, regional and local energy problems through education, research and public service.

GRADUATE PROGRAMS IN ENERGY ENGINEERING AND POLICY

Interdisciplinary programs in energy engineering and policy lead to the master's degree in the various engineering disciplines, operations research and management.

Common to all programs are two interdisciplinary courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
</tr>
<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
<td>3</td>
</tr>
</tbody>
</table>

These two courses are cross-listed in all participating departments and are accepted as departmental courses. Students may enter the energy program in one of two ways:

1. Admission through regular departments with admission and requirements determined by the departments for the M.S. degree.
2. Enrollment for a Certificate in Energy Policy and Engineering through a participating department.

DEGREE AND CERTIFICATE REQUIREMENTS

1. Departmental Master of Science Degree (e.g., master of science in mechanical engineering and certificate in energy policy and engineering).
   a. Student must satisfy minimum requirements of master of science program in the department.
   b. Student must complete the two required interdepartmental courses, ES 927 and ES 928. Another interdepartmental energy-related course (e.g., ES 929 Selected Topics in Energy) may be substituted for ES 928 with permission of the energy program adviser.
   c. Student must complete four additional courses from among the list of energy electives. At least two courses must be from a single energy elective category; i.e., these four courses may not be from different categories. The energy elective categories are the broad functional classifications listed under electives.

2. Certificate in Energy Policy and Engineering
   On completion of ES 927 and ES 928 and two energy electives from a single category, a certificate in energy policy and engineering will be awarded.

TYPICAL PROGRAMS

Chemical Engineering

<table>
<thead>
<tr>
<th>Course</th>
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<th>Units</th>
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<tr>
<td>CH 631-632</td>
<td>Transport Phenomena I, II</td>
<td>6</td>
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<tr>
<td>CH 771-772</td>
<td>Chemical Engineering</td>
<td></td>
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<tr>
<td>CH 781</td>
<td>Chemical Process Kinetics</td>
<td>3</td>
</tr>
<tr>
<td>CH 821</td>
<td>Process Dynamics &amp; Control*</td>
<td>3</td>
</tr>
<tr>
<td>CH 902</td>
<td>Guided Studies</td>
<td>6</td>
</tr>
<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
</tr>
<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
<td>3</td>
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<tr>
<td>Energy electives</td>
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</table>

Civil Engineering

Required courses dependent upon C.E. option selected

<table>
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<tr>
<th>Course</th>
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<th>Units</th>
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<tbody>
<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
</tr>
<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
<td>3</td>
</tr>
<tr>
<td>Energy electives (4 courses)</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Additional energy electives or other electives approved by departmental graduate adviser

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 665</td>
<td>Microeconomic Models*</td>
<td>3</td>
</tr>
<tr>
<td>IE 666</td>
<td>Macroeconomic Models*</td>
<td>3</td>
</tr>
<tr>
<td>IE 674</td>
<td>Economic Models &amp; Methods</td>
<td>3</td>
</tr>
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<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
</tr>
<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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<tr>
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Economic Systems

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<tr>
<td>EL 531</td>
<td>Probability</td>
<td>3</td>
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<tr>
<td>EL 611</td>
<td>Signals, Systems and Transforms</td>
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Electrical Engineering

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<tr>
<td>CH 631-632</td>
<td>Transport Phenomena I, II</td>
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<td>CH 771-772</td>
<td>Chemical Engineering</td>
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*Also energy elective
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<td>Intro to Power System Engineering*</td>
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<td>Intro to Power System Planning*</td>
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<td>EL 666</td>
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<td>EL 671</td>
<td>Fields and Waves</td>
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<td>Energy Policy Issues</td>
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<td>Energy Resources and Conversion Technology</td>
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**Recommended Electives**

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<tbody>
<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
<td>3</td>
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<tr>
<td>EL 621</td>
<td>Feedback Control I*</td>
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<tr>
<td>EL 647</td>
<td>Power Electronics*</td>
<td>3</td>
</tr>
<tr>
<td>EL 663</td>
<td>Electrical Transients in Power Systems*</td>
<td>3</td>
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<td>EL 664</td>
<td>Relay Fault Protection*</td>
<td>3</td>
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<tr>
<td>EL 668</td>
<td>Electric Drives I*</td>
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<tr>
<td>EL 669</td>
<td>Electric Drives II*</td>
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<tr>
<td>EL 961-2</td>
<td>Selected Topics in Power I, II and/or electives approved by departmental graduate adviser</td>
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**Energy Management**

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Electives: select two

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<td>Theories of Complex Organizations*</td>
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<td>MG 640</td>
<td>Resource Economics*</td>
<td>3</td>
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<td>MG 664</td>
<td>Legal Environment of Business*</td>
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<td>MG 865</td>
<td>Research, Development and Management of Innovation*</td>
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<td>Technology Management and Policy*</td>
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Additional electives approved by management division graduate adviser: 24 credits

**Industrial Engineering**

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<td>Statistical Quality Control*</td>
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<td>IE 619</td>
<td>Production Planning and Control</td>
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<tr>
<td>IE 628</td>
<td>Operations Research: Stochastic Models*</td>
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Major electives: 12 credits

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<tbody>
<tr>
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<td>Energy Policy Issues</td>
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<td>Energy Resources and Conversion Technology</td>
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**Metallurgy**

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<tr>
<td>MT 610</td>
<td>Metallurgical Thermodynamics</td>
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<td>MT 620</td>
<td>Plastic Deformation and Fracture</td>
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<tr>
<td>MT 640</td>
<td>Reactions in Solids</td>
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<td>Energy Policy Issues</td>
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<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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**Aeronautics and Astronautics and Mechanical Engineering**

(Thermal fluids/energy option)

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<tr>
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<td>Thermodynamics I*</td>
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<tr>
<td>AM 710</td>
<td>Convection</td>
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<tr>
<td>AM 740</td>
<td>Fluid Dynamics</td>
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<tr>
<td>AM 971-72</td>
<td>Seminar on Mechanical and Aerospace Engineering</td>
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Major area electives: 12 credits

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<th>Course Title</th>
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<tbody>
<tr>
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<td>Energy Policy Issues</td>
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<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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Energy electives: 9 credits

**Mechanical Engineering**

(Mechanical analysis and design option)

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<td>AM 601-02</td>
<td>Stress Analysis I, II</td>
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<td>AM 651-2</td>
<td>Advanced Dynamics I, II</td>
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<tr>
<td>AM 653-54</td>
<td>Dynamics of Machines: Mechanical Vibrations</td>
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<tr>
<td>AM 971-72</td>
<td>Seminar on Mechanical and Aerospace Engineering</td>
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Major area electives: 6 credits

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<td>Energy Policy Issues</td>
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<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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Energy electives: 12 credits

**Additional Electives**

- Energy electives (12 credits)
- Additional electives approved by departmental graduate adviser (9 credits)
- Total: 36 credits
Energy electives
Additional energy electives, electives approved by departmental graduate adviser, and project or thesis. 9

Nuclear Engineering
NU 601 Intro. Nuclear Engineering I* 3
NU 602 Intro. Nuclear Engineering II* 3
NU 603 Nuclear Engineering Lab. I* 3
NU 604 Nuclear Engineering Lab. II* 3
NU 606 Radiation Protection 3
NU 607 Reactor Licensing Safety and Environment 3
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3
Energy electives and departmental electives 12

Operations Research
IE 600 Engineering Economy 3
IE 631 Linear Programming* 3
IE 650 Queueing Systems I 3
Major electives 12
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3
Electives 9

Transportation Planning and Engineering
TR 600 Transportation Studies and Characteristics 3
TR 601 Travel Demand Forecasting* 3
TR 629 Transportation Workshop 3
TR 630 Urban and Regional Planning Principles 3
TR 701 Traffic Operations, Control and Management* 3
TR 750 Transportation Economics 3
TR 830 Energy in the Transportation Sector* 3
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3

Energy electives and departmental electives 12

Transportation Management
MG 600 Management Process 3
MG 604 Managerial Accounting 3
TR 600 Urban Transportation and Land Use Systems 3

TR 751 Transportation Finance* 3
TR 757 Transportation Management 3
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3
TM 966 Project in Transportation Management 3
Departmental electives as selected 12

ACCEPTABLE ENERGY ELECTIVES

Energy Conversion
AM 761 Energy Conversion 3
AM 763 Solar Thermal Engineering I 3
AM 764 Solar Thermal Engineering II 3
AM 769 Special Topics in Energy Conversion 3
CH 760 Energy Resources, Conversion Technology, Distribution and Utilization 3
CH 791 Electrochemical Engineering 3
EL 564 Electromechanical Power Conversion 3

Energy Transfer Processes
AM 711 Convecive Heat Transfer 3
AM 712 Conductive Heat Transfer 3
AM 713 Radioactive Heat Transfer 3
AM 715/NJ 715 Heat Transfer 3
AM 716/NJ 716 Reactor Heat Transfer 3
AM 717 High Performance Heat Exchangers 3
AM 718 Multiphase Flows with Heat Transfer 3
CH 766 Process Heat Transfer 3

Environmental Impact of Energy Systems
AM 685 Noise and Acoustics I 3
AM 686 Noise and Acoustics II 3
AM 751/CE 763 Aerodynamics of the Urban Environment I 3
AM 752/CE 764 Aerodynamics of the Urban Environment II 3
CE 741 Analysis of Water Quality Systems 3
CE 747 Analysis of Stream and Estuary Systems 3
CE 752 Air Pollution 3
CE 753/CH 743 Dispersion of Pollutants in the Atmosphere 3
CE 756/CH 752 Air Pollution Engineering Control 3
TR 630 Principles of Urban and Regional Planning 3
TR 631 Methods of Urban and Regional Analysis in Planning 3
TR 640 Environmental Aspects of Transportation Projects 3

*Also energy elective.
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<td>CE 756</td>
<td>Air Pollution Analysis</td>
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<td>Air Pollution Effects</td>
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**Fluid Energy Systems**

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<tr>
<td>AM 718</td>
<td>Multiphase Flows with Heat Transfer</td>
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<tr>
<td>AM 746</td>
<td>Fluid Dynamics of Rotating Machinery</td>
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<tr>
<td>AM 749</td>
<td>Magnetofluid Dynamics</td>
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**Machinery**

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<tr>
<td>EL 668</td>
<td>Electric Drives I</td>
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<tr>
<td>EL 669</td>
<td>Electric Drives II</td>
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<td>AM 746</td>
<td>Fluid Dynamics of Rotating Machinery</td>
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**Management and Economics of Energy Systems**

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<tr>
<td>NU 721</td>
<td>Economics of Nuclear Power and Radiation</td>
<td>3</td>
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<tr>
<td>MG 803</td>
<td>Economic Environment of Management</td>
<td>3</td>
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<tr>
<td>MG 631</td>
<td>Organization Theory</td>
<td>3</td>
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<td>MG 664</td>
<td>Management and the Legal System</td>
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<td>MG 800</td>
<td>Policy Planning and Analysis</td>
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<td>MG 805</td>
<td>Research, Development and Management of Innovation</td>
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<td>MG 866</td>
<td>Technology Management and Policy</td>
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<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
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<tr>
<td>IE 620/MG 810</td>
<td>Project Planning and Control</td>
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<tr>
<td>MG 757</td>
<td>Technology Transfer to Developing Countries</td>
<td>3</td>
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<tr>
<td>IE 665</td>
<td>Microeconomic Models</td>
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<td>IE 666</td>
<td>Macroeconomic Models</td>
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<td>MG 640</td>
<td>Resource Economics</td>
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<tr>
<td>MG 671</td>
<td>Business and Economic Forecasting</td>
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<td>MG 672</td>
<td>Technological Forecasting</td>
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<td>CH 611</td>
<td>Unit Processes of Chemical Technology</td>
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<tr>
<td>CE 759</td>
<td>Engineering Aspects of Regional and Master Planning</td>
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<td>AM 765</td>
<td>Energy Conversion and Environmental Control</td>
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**Materials**

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<tbody>
<tr>
<td>NU 726</td>
<td>Metallurgy of Nuclear Reactor Materials</td>
<td>3</td>
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<tr>
<td>MT 652</td>
<td>Special Topics in Advanced Engineering Metallurgy II: Nondestructive Testing</td>
<td>3</td>
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<td>MT 700</td>
<td>Welding Metallurgy</td>
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<td>MT 715</td>
<td>Corrosion and Oxidation Mechanisms in Metals</td>
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<td>CH 917</td>
<td>Introduction to Polymeric Materials I</td>
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**Nuclear Energy**

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<td>NU 601</td>
<td>Intro. Nuclear Engineering I</td>
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<td>Nuclear Engineering Lab. I</td>
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<td>NU 604</td>
<td>Nuclear Engineering Lab. II</td>
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<td>NU 619/EL 667</td>
<td>Introduction to Thermonuclear Power</td>
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<td>NU 721</td>
<td>Economics of Nuclear Power</td>
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**Plasma and Controlled Fusion**

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<td>Introduction to Plasma Physics</td>
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<td>Introduction to Thermonuclear Power</td>
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**Power Plant Construction and Engineering**

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<td>CE 625/AM 661</td>
<td>Structural Dynamics</td>
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<tr>
<td>CE 627</td>
<td>Dynamic Responses of Civil Engineering Structures</td>
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<td>CE 711</td>
<td>Hydraulic Design of Structures</td>
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<td>CE 724</td>
<td>Water Resource Planning</td>
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<td>CE 890</td>
<td>Earthquake Engineering I</td>
<td>3</td>
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<tr>
<td>CE 891</td>
<td>Earthquake Engineering II</td>
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<tr>
<td>AM 605</td>
<td>Limit Analysis of Structures</td>
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<tr>
<td>AM 630</td>
<td>Design Methods for Power Plant Structures</td>
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<tr>
<td>AM 632/CE 632</td>
<td>Piping Analysis</td>
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<td>AM 634</td>
<td>Pressure Vessel Analysis</td>
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**Safety, Reliability and Control of Energy Systems**

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<td>AM 675</td>
<td>Mechanical Servomechanisms I</td>
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<td>AM 676</td>
<td>Mechanical Servomechanisms II</td>
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<tr>
<td>CH 821</td>
<td>Process Dynamics and Control</td>
<td>3</td>
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<tr>
<td>EL 617/IE 685</td>
<td>System Reliability</td>
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<tr>
<td>EL 618/IE 686</td>
<td>Component Reliability</td>
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<td>EL 621</td>
<td>Feedback Control I</td>
<td>3</td>
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<td>EL 622</td>
<td>Feedback Control II</td>
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<td>Power Electronics</td>
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<td>Intro. to Power System</td>
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<td>EL 663</td>
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<td>Relay Fault Protection</td>
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<td>EL 666</td>
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<tr>
<td>NU 607</td>
<td>Reactor Licensing, Safety and Environment</td>
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<td>NU 712</td>
<td>Radiation Shielding</td>
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<tr>
<td>IE 611</td>
<td>Statistical Quality Control</td>
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<td>IE 612</td>
<td>Advanced Quality Control</td>
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<td>IE 785</td>
<td>Human Factors in Engineering Design</td>
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<td>IE 775</td>
<td>Industrial Safety Engineering</td>
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**System Organization**

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<td>Introduction to Power System Planning</td>
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<tr>
<td>EL 723</td>
<td>System Optimization Methods</td>
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<tr>
<td>IE 614</td>
<td>Modeling of Social Systems I</td>
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<tr>
<td>IE 615</td>
<td>Modeling of Social Systems II</td>
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<td>IE 621</td>
<td>Facility Layout and Design</td>
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<td>IE 627</td>
<td>Operations Research</td>
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<tr>
<td>IE 628</td>
<td>Operations Research Stochastic Models</td>
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REQUIRED COURSES

Registration for these courses is restricted to graduate students enrolled in the energy program, except as permitted by the energy program adviser.

ES 927 Energy Policy Issues 2½:0:3

ES 928 Energy Resources and Conversion Technology 2½:0:3
Summary of present energy resources and global energy requirements. Twentieth century advances in science and technology now being applied or soon to be applied to United States energy economy. Attention to principles behind practical devices and to limitation imposed by fundamental laws of physics. Fossil fuel power generation, nuclear fission and fusion, solar, magneto-hydrodynamic, and thermal differential converters. Chemical and mechanical storage, new electrical distribution systems.

ES 929 Selected Topics in Energy 2½:0:3
Topics of current interest: energy economics, energy resources, social impact of energy technologies. Available for credit in lieu of ES 926, when offered, as the second required course of the energy program.

PARTICIPATING FACULTY

STEERING COMMITTEE

Edward S. Cassetty, Jr., Professor of Electrical Engineering
Chairperson, Energy Program Steering Committee

Irving Cadott, Professor of Physical and Engineering Metallurgy

Joachim I. Weindling, Professor of Operations Research and System Engineering

Anthony J. Weiner, Professor of Management

Raul R. Cardenas, Jr., Associate Professor of Civil and Environmental Engineering

Leonard I. Stiel, Associate Professor of Chemical Engineering

Romualdas Sviedrys, Associate Professor of Social Sciences

Richard S. Thorsen, Associate Professor of Mechanical and Aerospace Engineering

Richard E. Wener, Visiting Assistant Professor of Social Sciences

FACULTY PARTICIPANTS

Raphael Aronson, Professor of Nuclear Engineering and Physics

Martin H. Bloom, Institute Professor

Alvin S. Goodman, Professor of Civil and Environmental Engineering

Seymour Kaplan, Associate Professor of Operations Research

Enrico Levi, Professor of Electrical Engineering and Computer Science

Wheeler K. Mueller, Jr., Professor of Mechanical and Aerospace Engineering

Pasquale M. Sforza, Professor and Head of Mechanical and Aerospace Engineering

Richard A. Haddad, Associate Professor of Electrical Engineering and Computer Science

Melvyn Meer, Assistant Professor of Management

Alan H. Molot, Associate Professor of Civil and Environmental Engineering

Zivan Zabar, Associate Professor of Electrical Engineering and Computer Science
HUMANITIES AND COMMUNICATIONS

The Department of Humanities and Communications offers undergraduate degree programs with concentrations in journalism and technical writing and in the humanities. The department also offers a unique program in specialized journalism leading to an M.S. degree. The graduate program and the undergraduate concentrations are designed to take advantage of the strengths of a technological university—and so are particularly beneficial to students who wish to combine a strong interest in the humanities or journalism and technical writing with an interest in science and technology.

In a world of narrowly-focused specialists, human progress depends upon those who can synthesize knowledge and communicate it with real understanding. Such persons are not locked into rigid academic disciplines and patterns of thinking; they are intellectually comfortable in the sciences as well as in the arts and humanities. While such persons are rare, they are in demand in virtually every profession we now know, and they can expect to fill vital roles in fields that are only now being explored. Our programs are designed to give men and women in the humanities and in communications an integrated education.

In addition to these programs, the department plays an essential role in the education of students who are majors in other departments. Today's engineers and scientists must have a solid education in the humanities to prepare them for the complex tasks they face. They must have the ability to make well-reasoned decisions involving human values implicit in technological options, an understanding of the many ways in which human beings have seen and understood both themselves and the natural and social world, and the ability to communicate effectively in a variety of formats.

In the freshman year, all students admitted to Polytechnic will be placed at the appropriate level in the freshman English sequence. On the basis of SAT verbal scores and an English composition placement test administered by the department, most students will be placed in one of the standard freshman courses (HU 101 or HU 103); some may be exempted and placed in HU 200, the second required course in the sequence; others may first be required to take an introductory course in English (HU 008 or HU 009) with a reduced course load (a maximum of 14 credits).

After completing HU 101 (or HU 103) and HU 200, the non-major is encouraged to complete a sequence of courses in one of the disciplines within the department—literature, art and music, philosophy, religion, or modern languages—or to put together a combination of courses that will provide a coherent introduction to the humanities. Courses in public speaking and technical writing are especially practical for students preparing for a professional career in engineering or science. Advisers in the department are available to help students work out such a program. See Degree Requirements.

UNDERGRADUATE PROGRAMS

The Department of Humanities and Communications offers a bachelor of science degree with a concentration in one of several areas.

Concentration in Journalism and Technical Writing

Our graduates have gone into successful careers in journalism, science writing and technical writing. Science and technical writers in particular—writers with the skills of the journalist combined with a strong interest in science and technology—will continue to be in great demand throughout the 1980's. In these fields, professional status and salary are virtually on a par with those of engineers. Majors in journalism and technical writing will work out a program of studies in consultation with a departmental adviser. They may specialize in print journalism, broadcast journalism, science journalism, technical writing or corporate communications.

Concentration in the Humanities

For students wishing to pursue a degree in the humanities, the department offers concentrations in English, American and comparative literature; philosophy, German language and literature; and general humanistic studies (a multidisciplinary major in the humanities). Here, too, students will work out a program of studies in consultation with a departmental adviser. Students who wish to obtain certification for teaching in public schools in the New York City area should plan to take the necessary education courses at another institution. Credit will be given for these education courses as free electives in meeting degree requirements.

REQUIREMENTS FOR THE BACHELOR'S DEGREE

<table>
<thead>
<tr>
<th>Core Curriculum</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities (HU 101 and HU 200)</td>
<td>6</td>
</tr>
<tr>
<td>Social Sciences (SS 104 and one other)</td>
<td>6</td>
</tr>
<tr>
<td>Mathematics</td>
<td>8</td>
</tr>
<tr>
<td>Science</td>
<td>12</td>
</tr>
<tr>
<td>Interdisciplinary courses</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>57</td>
</tr>
</tbody>
</table>

*IS 140-141 may be taken in place of HU 200 and SS 104. See the Humanities and Social Sciences requirements on page 28.
Concentrated Studies in the Major 33

Electives
- Humanities electives 6
- Social Sciences electives 6
- Free electives 24

Total credits required for graduation 126

The dual major—A number of students elect to pursue a dual major leading to two undergraduate degrees—one in humanities and without a concentration in journalism and technical writing and another in engineering or science. Besides completing all requirements for the degree in engineering or science, the student must complete an additional 33 credits of communications courses in the Department of Humanities and Communications. These courses must be approved by a departmental adviser.

Interdisciplinary Studies—The purpose of the interdisciplinary studies program, sponsored by the Department of Humanities and Communications and the Department of Social Sciences, is to enhance the humanistic side of the student’s education. The program promotes courses, seminars, and special lectures demonstrating the fruitfulness of interdisciplinary approaches to human knowledge. IS 140-141 is a year-long, unified humanities/social sciences sequence intended for freshman students. This sequence may be taken in place of the HU 200/SS 104 requirement for undergraduates. IS 145 and IS 146 may be taken as advanced humanities/social sciences electives.

Core Curriculum—A contemporary liberal arts core curriculum, representing a new vision of liberal education, is available for students in the Bachelor of Science degree programs in Social Sciences or the Humanities. For a full description, see section “Contemporary Liberal Arts Core Curriculum,” page 99.

GRADUATE PROGRAMS

Specialized Journalism

To be eligible for admission as a graduate student specializing in science, technical and financial writing and journalism, an applicant must hold a baccalaureate degree or its equivalent from an acceptable institution of higher learning. The department admits students holding undergraduate degrees in the humanities, journalism, engineering, the sciences, and the social sciences.

Applicants are expected to have a good command of English and should have taken as undergraduates at least one semester of college-level mathematics and one year of college-level science (to be met by any combination of courses in biology, chemistry, physics, geology, geography, engineering and history of science). Applicants lacking any of these courses may be matriculated on a provisional basis—as long as they meet all other requirements for admission—but will be required to take undergraduate courses to fulfill the basic requirements for admission. No graduate credit will be given for such undergraduate courses taken to meet deficiencies.

In general, applicants should have a minimum undergraduate grade point average of 3.0 from an accredited college or university. However, candidates with a lower grade-point average may be considered if they have demonstrated success in some area of professional writing. Others with a lower grade-point average may be admitted as non-degree candidates. Applicants are not required to take the Graduate Record Examination.

FIELDS OF SPECIALIZATION

Financial Reporting

Financial and business reporting calls for the professional journalist to write about business and financial developments and trends for both the knowledgeable business professional and market analyst as well as for the general public. The writer should have a solid background in economics and a clear understanding of business and financial concepts and terminology (including the workings of the various exchanges) in order to report and interpret developments accurately and understandably. Clear, crisp, concise writing is a must.

Trade-Magazine Journalism

Trade-magazine journalism entails writing and editing news and feature articles for both technical and marketing-oriented publications serving a particular industry. Such publications may be owned by independent publishing companies, professional societies, or large corporations.

Medical and Science Reporting

Professional medical and science writers or editors will work on professional magazines serving physicians, nurses and other technical and scientific personnel; on the news staffs of print and broadcast media; on public relations staffs of pharmaceutical houses and major hospitals, medical schools and research centers; in the writing departments of major corporations; and in textbook editing. In addition to having the ability to write clearly and succinctly, writers and editors in this field should have a sound background in the sciences.

Industrial Advertising and Public Relations

Industrial advertising and public relations are concerned with the promotion of a corporation’s
products and capability to sell such products to industrial clients rather than to the general public. Industrial advertising involves copywriting, choosing graphics, selecting media, organizing ad campaigns and performing market research. Those entering this profession work as copywriters, account executives, advertising managers and media directors.

Industrial public relations has the same overall goal as industrial advertising—to promote a positive corporate image to industrial clients. Public relations workers issue news releases on new products and technological advances to the trade and business press serving their client’s industry, hold press conferences to announce new products and/or technology developed by the client company, prepare feature articles on the company's products for publication in trade magazines and technical journals, write speeches for top engineering and management personnel and prepare corporate literature (product brochures, annual reports, house organs and other technical and semi-technical material) for dissemination to corporate customers.

Technical Writing

Technical writers—also referred to as publications engineers and engineering writers—gather, organize, write and edit material of a technical and scientific nature for management and technical personnel within their own company as well as for customers and prospective customers. Such information takes a variety of forms: proposals to the federal government and to other corporations for primary and sub-contract work, progress reports on government-sponsored programs, manuals for use by customer-service and maintenance personnel, corporate-capability brochures and technical and scientific news releases. In addition, the technical writer may be called upon to write speeches and trade-magazine articles for the company's scientists and engineers.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The M.S. degree requires 36 units of graduate work. Eighteen of these units are to be taken in required courses. All students must take JW 605 (Libel Law and Press Ethics), JW 701 (Specialized Project in Professional Writing) and four courses (12 units) selected from the following list in consultation with an adviser:

### Units

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>JW 600 Introduction to Specialized Journalism</td>
<td>3</td>
</tr>
<tr>
<td>JW 601 Style for the Professional Writer</td>
<td>3</td>
</tr>
<tr>
<td>JW 602 Proposal Writing</td>
<td>3</td>
</tr>
<tr>
<td>JW 603 Reporting on Science, Technology and Medicine</td>
<td>3</td>
</tr>
<tr>
<td>JW 604 Graphics and Production Techniques</td>
<td>3</td>
</tr>
<tr>
<td>JW 607 Writing News for Radio and Television</td>
<td>3</td>
</tr>
</tbody>
</table>

The remaining 18 units are to be taken in elective courses. Normally, students select electives from among the remaining graduate courses offered in the department. But students who wish to enhance their scientific and technical knowledge may take a maximum of nine credits of graduate courses in other departments of Polytechnic. Approval for this option must be given by the head of the department.

Elective courses are usually conducted as workshops, providing students with the types of writing and editing assignments they would receive were they actually working in the field.

While students select their individual programs in consultation with an adviser, the department strongly recommends that they select most of their electives in one of the five specializations below.

### Financial Reporting

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>JW 620 Financial and Business Reporting</td>
<td>3</td>
</tr>
<tr>
<td>JW 621 Reporting and Editing for the Business Press</td>
<td>3</td>
</tr>
<tr>
<td>JW 622 Writing Copy for Industrial Public Relations</td>
<td>3</td>
</tr>
<tr>
<td>JW 623 Publications Management and Budgeting</td>
<td>3</td>
</tr>
<tr>
<td>JW 701 Special Project in Professional Writing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Trade-Magazine Journalism

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>JW 620 Financial and Business Reporting</td>
<td>3</td>
</tr>
<tr>
<td>JW 621 Reporting and Editing for the Business Press</td>
<td>3</td>
</tr>
<tr>
<td>JW 622 Writing Copy for Industrial Public Relations</td>
<td>3</td>
</tr>
<tr>
<td>JW 624 Writing Product-Information Copy</td>
<td>3</td>
</tr>
<tr>
<td>JW 701 Special Project in Professional Writing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Medical and Science Reporting

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>JW 603 Reporting on Science, Technology and Medicine</td>
<td>3</td>
</tr>
<tr>
<td>JW 621 Reporting and Editing for the Business Press</td>
<td>3</td>
</tr>
<tr>
<td>JW 625 Advanced Medical Reporting</td>
<td>3</td>
</tr>
<tr>
<td>JW 626 Medical Public Relations</td>
<td>3</td>
</tr>
<tr>
<td>JW 627 Writing Copy on Pharmaceuticals and Drugs</td>
<td>3</td>
</tr>
<tr>
<td>JW 701 Special Project in Professional Writing</td>
<td>3</td>
</tr>
</tbody>
</table>

### Industrial Advertising and Public Relations

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>JW 621 Reporting and Editing for the Business Press</td>
<td>3</td>
</tr>
<tr>
<td>JW 622 Writing Copy for Industrial Public Relations</td>
<td>3</td>
</tr>
<tr>
<td>JW 624 Writing Product-Information Copy</td>
<td>3</td>
</tr>
<tr>
<td>JW 628 Writing Industrial Advertising Copy</td>
<td>3</td>
</tr>
<tr>
<td>JW 629 Writing the Marketing Report</td>
<td>3</td>
</tr>
<tr>
<td>JW 701 Special Project in Professional Writing</td>
<td>3</td>
</tr>
</tbody>
</table>
Technical Writing
JW 603 Reporting on Science, Technology and Medicine 3
JW 622 Writing Copy for Industrial Public Relations 3
JW 624 Writing Product-Information Copy 3
JW 630 Basic Technical Report Writing I 3
JW 631 Basic Technical Report Writing II 3
JW 632 Writing Technical Manuals 3
JW 701 Special Project in Professional Writing 3

CERTIFICATE PROGRAM IN A FIELD OF SPECIALIZATION
A certificate in specialized journalism is available to students completing five courses with a grade of B or higher. The courses must be taken in a prescribed sequence worked out with an adviser. Students enrolled in the certificate program must meet the same rigorous standards of performance required of those working for an M.S. degree. At any time during enrollment, or following the awarding of the certificate, students in this program may transfer into the master's degree program provided that their performance has been satisfactory and that they meet the standards for admission set by the department. Transfer into the master's program, however, may not mean automatic acceptance of every course student have taken while working toward the certificate. Acceptance of credits will depend on the area of specialization in which students plan to work for the degree.

ENGLISH AND HUMANISTIC STUDIES AND MODERN LANGUAGES
Advanced courses and seminars in the humanities will be offered from time to time for graduate students in the sciences, engineering and the social sciences.
HU 605 (Report Writing) is regularly offered by the department. Some departments permit graduate students to construct a minor in the humanities to fulfill part of their requirements for an advanced degree; advisers in the Department of Humanities are available to recommend appropriate courses for such a minor.

UNDERGRADUATE COURSES

FRESHMAN ENGLISH SEQUENCE

HU 008 Reading and Writing in English as a Second Language 6:0:0
English as a second language at the high-intermediate level. Concentration on development of grammatical control in writing and on improved comprehension of college-level texts. Practice in listening and speaking. Intensive preparation in language skills for academic and professional purposes. Graduate students may register with permission of department. Admission by placement examination.

HU 009 Introductory Composition 6:0:0
Intensive course in reading comprehension and composition skills for native speakers of English who have not been adequately prepared for college composition. Emphasis on development of control over standard written English and fluency in writing. Admission by placement examination.

HU 101 College Composition 3:0:3
Techniques of effective communication in English. Essay writing, editing, proofreading. Emphasis on fluency, flexibility, precision and imagination in writing and thinking. Introduction to use of source material in writing. Admission by placement examination.

HU 103 College Composition in English as a Second Language 5:0:3

HU 200 Introduction to Literature 3:0:3
Study of works of poetry, fiction and drama that illustrate prevailing themes and conflicts of Western literature. Course also provides advanced work in more structured forms of writing: critical analysis, formal report, research paper. Some sections may be devoted to special themes. Prerequisite: HU 101 or HU 103 or advanced placement.

Please note: HU 200 or its equivalent is a prerequisite for all undergraduate HU courses listed below except for HU 105 (prerequisite: HU 101 or HU 103), and HU 121 (no prerequisite), and a few courses with more advanced prerequisites as listed.

JOURNALISM AND TECHNICAL WRITING

HU 105 Advanced Composition 3:0:3
Intensive training in lucid expository writing. Emphasis on gathering and organization of factual material into larger units of composition. Methods of research and use of library. Topics based on models of expository prose. Long paper.

HU 106 Writing for Publication: The Magazine Article 3:0:3
Emphasis on developing the student's interviewing and writing skills to produce a medium-to-long-length magazine article. With instructor's help, students develop a story idea on a technical or non-technical subject, carry out the necessary library research and personal interviews and write the piece for a specific publication. Students are encouraged to publish their work, although this is not a specific course requirement. Students also examine editorial practices of various popular magazines and technical magazines and learn how successful magazine articles are put together.

HU 108 News Writing 3:0:3
Application of good writing to journalistic practice. Workshop to guide student in all basic news writing techniques: Writing of leads, style and structure of body of news stories. Methods of news gathering. Writing of different types of news stories—meeting, speech, interview, human interest, interpretation.

HU 109 Feature Writing 3:0:3
Theory and practice of writing short or moderate-length magazine articles on general subjects. Principles and practices of writing in readable style. Guidance in selecting interesting topics, in market study, in writing, in outlining and writing minimum of three articles.

HU 110 Basic Report Writing I 3:0:3
Application of fundamentals of report writing to short, informal papers written by scientists and engineers in actual business situations; technical correspondence, memoranda, trip reports, periodic reports and new-product information sheets. Emphasis on writing summaries, process ad technical descriptions, instructions, analyses. Attention is given to effective style, organization of material and mechanics. Students learn
to coordinate tables, graphs and other illustrative matter with
textual matter.

H U 111 Basic Report Writing I 3:0:3
Intensive practice in writing the longer technical forms com-
monly used in industry. Emphasis is given to writing technical
proposals, sections of manuals, letter reports, formal reports,
technical sales literature, and semi-technical and technical ar-
ticles for trade journals.

H U 112 Advanced Copyediting Techniques 3:0:3
Course designed to improve the student's editorial skills
through intensive practice in writing headlines, decks and sub-
heads for both general and industrial publications and through
assignments in editing, revising and rewriting copy intended for
a variety of publications. Emphasis on writing leads and in
reorganizing garbled copy. Newspaper and magazine page
layout and makeup. Prerequisite: HU 105.

H U 113 Writing for Advertising and
Public Relations 3:0:3
The principles of writing effective advertising copy and pub-
licity releases with an emphasis on the industrial side. Stu-
dents write product ads, brochure copy, product data sheets,
news releases, short articles for trade journals, copy for house
organs and speeches. Course covers the preparation and im-
plementation of a typical advertising campaign and the ar-
range ment of a press conference. Attention is given to layout
of ad copy and to accompanying color, design, typographic
and illustrative features. Prerequisite: HU 105.

H U 114 Libel Law and Ethical Issues
in Journalism 3:0:3
Introduction to what libel is and how the writer can avoid its
many pitfalls. Course covers both the complete and partial de-
fenses raised during libel suits and the possible damages
awarded, the principle of "fair comment and criticism," crim-
nal and civil libel, and one's right to privacy vs. the public's
"need to know." The course also takes up many of the ethical
issues facing journalists and other writers today, issues such
as writing about new products and technology believed to be
defective or hazardous, pornography and the courts, writing
in good taste, shield laws, gag orders and copyrights.

H U 115 Reporting and Writing about
Science and Technology 3:0:3
Students will learn how to interview scientists and engineers
and how to present the information obtained in a format un-
derstandable to the layman. They will write both news and fea-
ture stories, and will be encouraged to publish their better
pieces.

H U 121 Public Speaking 3:0:3
Training and practice in speaking before a group, preparation
of material for oral presentation, extemporaneous speaking,
individual criticism by instructor and fellow students.

H U 125 Reporting and Writing
for the Wire Services 3:0:3
Students will report, write, and edit the news under the pres-
sure of tight deadlines (often the same day). Many assign-
ments will require field research as this course attempts to
simulate a wire-service reporter's daily experiences. Trips to
AP andUPI headquarters will be arranged. Emphasis will be
on reporting accuracy and thoroughness as well as on good
journalistic style. Wire-service history and editorial practices
will be covered.

H U 130 Creative Writing I 3:0:3
An introduction to the art and craft of writing poetry, fic-
tion and drama. Students encouraged to experiment with all
genres and discover where their talents lie. Emphasis through-
cut on students' own work. Weekly written assignments dis-
cussed and criticized in class.

H U 131 Creative Writing II 3:0:3
An advanced course in the art and craft of writing poetry, fic-
tion and drama. Application of individual writing talents to
specific forms. Development of intelligent critical responses to
all forms of literature. Weekly written assignments, plus one
longer writing project: a story, play or small collection of
poems. Prerequisite: HU 130 or permission of instructor.

H U 135 Introduction to Corporate Communications 3:0:3
An intensive study, through a review of case histories and writ-
ing assignments requiring field research, of all aspects of
editorial work in the communications department of a medium-
sized or large corporation. Students will be required to re-
search, write and edit copy for press releases, newsletters,
proposals, house organs, community-relations campaigns,
brochures, and annual reports. Course will emphasize busi-
ness correspondence, short nontechnical memos and reports,
and the formats for writing the minutes of meetings and job
descriptions.

H U 136 Writing Annual Reports 3:0:3
The single most important document produced by a corpora-
tion is its annual report. Students will learn and practice the
procedures by which this publication is written and produced:
planning, scheduling, researching, writing, editing, graphics
and production.

H U 140 Proposal Writing 3:0:3
Solicited and unsolicited proposals in both the government
and private sectors are covered. Emphasis is given to the ele-
ments of a typical proposal, such as statement of the problem,
technical discussion, how a team organizes to perform the
work, fiscal information, technical competence of the company
to perform the task, key personnel, etc. Students will be re-
quired to prepare an outline and then to write a proposal on
a specific topic worked out between them and the instructor
as the major course assignment.

H U 141 Graphics and Production Techniques 3:0:3
An introduction to graphic design and production techniques
and procedures for technical writers and editors, with em-
phasis on magazine layout and producing technical reports,
manuals, and proposals. Topics covered will include compos-
ation methods, copy preparation and processing, page
makeup, mechanics, printing processes, magazine imposition.
Course will be conducted in a workshop atmosphere.

H U 142 Writing Operations and
Maintenance Manuals 3:0:3
Intensive instruction in preparing industrial and military tech-
nical instruction manuals covering all phases of operation and
maintenance of various kinds of equipment. Training in how to
write these documents according to government specifica-
tions. The compilation of technical information for the manual
and its use in conjunction with extensive graphics and tabular
material (such as troubleshooting charts) are emphasized in
practical writing situations. Assembling of a parts list is cov-
ered.

H U 150-151 Special Projects
in Communications each 3:0:3
Independent work in an area of interest in the field of com-
munications selected by the student in consultation with in-
structor. For majors only.

H U 155 Special Topics in Journalism 3:0:3
Courses on special topics in journalism will be offered from
time to time by the staff of the department or by visiting scho-
Iars. The specific titles and prerequisites will be announced
prior to registration. May be repeated for credit.
HU 160 Writing the News for TV and Radio 3:0:3
Intensive practice in the special format required for writing news for TV and radio. Students will rewrite newspaper articles and rewrite copy in the style necessary for these formats. They will also practice broadcasting the news and writing newscasts under pressure. Prerequisites: HU 105 or permission of instructor.

HU 161 Writing and Producing Documentaries for Broadcast 3:0:3
Working in teams, students will research, write and narrate documentary radio and television broadcasts on pressing social, economic, political and scientific and technological issues. Emphasis will be on local topics. Course deals with production as well as the journalistic side of broadcasting. Students will study classic models at the Museum of Broadcasting.

LITERATURE
(See also Literature in Translation; ML 311-313, ML 318-319, and interdisciplinary studies.)

HU 201 Literature of Western Civilization I 3:0:3
Sources of modern ideals and values in ancient world: Greek drama, Plato, Lucretius, Bible, etc.

HU 202 Literature of Western Civilization II 3:0:3
Source of modern ideals and values from Middle Ages to 18th century: miracle plays, Shakespeare, Milton, Voltaire, etc.

HU 203 Literature of Western Civilization III 3:0:3
Intellectual and cultural, moral and spiritual values of modern world, examined in novels, drama, philosophy, poetry. Readings in literature of Romantic revolt, Goethe, Dostoevski, Brecht, Safrre, Satchenston, American and European verse.

HU 211 English Literature from Beowulf to 1800 3:0:3
Great tradition of English literature from Beowulf through Chaucer, Elizabethans and Jacobean to 1800.

HU 212 English Literature from 1800 to Present 3:0:3
Great tradition of English literature from Romanticism to present (Wordsworth, Byron, Dickens, Tennyson, Shaw, Conrad, Beckett and others).

HU 213 Science and Literature 3:0:3
With emphasis on modern period, examination of the literatures of scientific literature and imaginative literature devoted to and affected by science. Readings in such authors as Charles Darwin, T.H. Huxley, Bertolt Brecht, Sinclair Lewis, Arthur Koestler, Heinrich Kiephard, James Watson, Kurt Vonnegut, Isaac Asimov.

HU 222 Shakespearean Tragedies, Comedies, Histories 3:0:3

HU 251 American Literature to 1860 3:0:3
Puritan and neoclassic periods through romantic movement and rise of realism. Background and thought of Jonathan Edwards, Paine, Irving, Poe, Hawthorne, Emerson, Thoreau, Whitman, Twain, James and other representative writers.

HU 252 American Literature from 1860 to Present 3:0:3

HU 258 American Thought 3:0:3
Background, development and dynamics of American thought: Puritanism and conformity, individualism and collectivism, sentimentality and pragmatism. Americans as moral agents, as revealed in mass media and in readings in literature and philosophy.

HU 260 Contemporary American Poetry 3:0:3
Contemporary American poetry as affirmative expression of the human situation. Technical and philosophical analysis of such poets as Auden, Whitman, Stevens, Harte, Howells, Crane, Crane, Bellow and others.

HU 264 The Short Story 3:0:3
Theme, structure, technique of short stories by writers as diverse in style and philosophy as Chekhov, Twain, O. Henry, Mansfield, Lardner, Faulkner, Thaxter and Hemingway.

HU 272 Contemporary American Poetry 3:0:3
Contemporary American poetry as affirmative expression of the human situation. Technical and philosophical analysis of such poets as Auden, Whitman, Stevens, Harte, Howells, Crane, Crane, Bellow and others.

HU 283 Modern American Drama 3:0:3
Modern American drama, with emphasis on affirmative or negative statements regarding man's fate in the universe. Technical and philosophical analysis of works by O'Neill, Miller, Anderson, Heitman, Williams, Inge, Albee, etc. Discussion of selected contemporary American films.

HU 291 Short Fiction 3:0:3
Study of major writers of the novella (long short story) form. This course emphasizes the relationship between literature and ideas. Among the authors to be considered are Saul Bellow, Albert Camus, Joseph Conrad, Ernest Hemingway, Franz Kafka, Thomas Mann, Alexander Solzhenitsyn, Nathaniel West. Class discussions, cinematic presentations of some of the works and theatre visits are integral parts of the course.

HU 295 Literary Interpretation and Criticism 3:0:3

HU 297 English Language 3:0:3
History and development of English language. Readings in Old, Middle and Early Modern English. Emphasis on Middle English, as exemplified by selections from Chaucer's Canterbury Tales.

PHILOSOPHY AND COMPARATIVE RELIGION

HU 341 Introduction to Philosophy 3:0:3
An initial inquiry into problems, methods and terminology of Western philosophy through study and discussion of selected philosophical texts.

HU 344 Logic and Scientific Method 3:0:3
Basic principles and techniques of correct reasoning in sciences and daily life. Varieties of deductive and inductive inference, the use and misuse of language in reasoning. Emphasis on detection of common fallacies.
H U 3 4 8 Great Philosophers 3:0:3
Fundamental ideas of central figures in history and philosophy from Greece through 18th century. Particular emphasis on philosophies of Plato, Aristotle, Descartes, Hume, Kant.

H U 3 4 9 Recent Philosophy 3:0:3
An introduction to the major philosophical movements since Kant: Marxism, pragmatism, phenomenology and analytic philosophy.

H U 3 5 2 Philosophy of Science 3:0:3
Examination of central problems in theory of science and scientific methodology. Relation between science and philosophy, scope and objectives of natural sciences, role of mathematics in science, observation and experimentation, laws, theories, explanations; causality and induction.

H U 3 5 4 Social and Political Philosophy* 3:0:3
Examination of philosophical and ethical foundations of divergent sociopolitical theories and systems. Analysis of such concepts as justice, the good, freedom, authority, rights, as they appear in the thoughts of selected political philosophers.

H U 3 5 3 Comparative Religion I* 3:0:3

H U 3 5 4 Comparative Religion II* 3:0:3

M U S I C A N D F I N E A R T S

H U 3 7 1 Understanding of Music 3:0:3
Active, intelligent listening to masterpieces of Western music from its origins through each of the Baroque, Classical, Romantic, and Brahms. Major musical forms: concerto grosso, fugue, sonata, symphony, concerto, music drama, tone poem. Analysis of orchestra scores. Parallel trends in other arts and thought. A look at the changes in the social role of music.

H U 3 7 5 Modern Music 3:0:3
Music from 1850 to present: Wagner, Strauss, Mahler, Debussy, Stravinsky, Ives, Schönberg, Berg, Webern, Varèse. Revolt against romanticism; breakdown of traditional tonal-harmonic system; Polyaehmony, polytonality, pantonality; melodic fragmentation, aleatory and electronic music as expressions of the 20th century. A look at jazz, modern popular music and music of other cultures.

H U 3 8 2 Fine Arts I 3:0:3
Historical and analytical study of Western architecture, sculpture, painting, Egyptian, Greek, Roman architecture and sculpture. Gothic and Renaissance art. Parallel trends in other arts.

H U 3 8 3 Fine Arts II* 3:0:3
Historical and analytical study of Western architecture, sculpture, painting from 1600 to present. Baroque, neoclassic, romantic styles. Revolt against romanticism and quest for new artistic, decorative and lexicographic forms to express contemporary civilization.

H U 3 8 8 Art of Asia* 3:0:3
Architecture, sculpture, painting as cultural, social and religious expressions of India, China, Japan, Southeast Asia and Islamic world. Comparisons between Oriental and Occidental arts as media of thinking and feeling.

S P E C I A L T O P I C S

The following special topics courses will be offered from time to time by the staff of the department or by visiting scholars. The specific titles and prerequisites will be announced prior to registration. May be repeated for credit.

H U 3 0 0 Special Topics in Humanities 3:0:3
H U 3 0 1 Special Topics in Literature 3:0:3
H U 3 0 2 Special Topics in Philosophy 3:0:3

M O D E R N L A N G U A G E S

G E R M A N

M L 1 1 1 German I: Foundation Course 3:0:3
For students who have had no previous training in German. Audiolingual emphasis on developing proficiency in reading, comprehension, speaking. Early practice in reading original German prose and representative poems.

M L 1 1 2 German II 3:0:3
Continuation of basic foundation provided by course ML 111. Reading of original German prose, selections from Hesse, Kastner, Zweig, others. Prerequisite: ML 111 or equivalent.

M L 1 1 3 German III: Readings in German Literature Since 1800 3:0:3
Selected readings and discussion of significant works in prose, lyric, poetry and drama to acquaint student with outstanding writers, ideas, movements in German literature. May be taken by students who have had secondary school training in German. Prerequisite: ML 112 or equivalent.

M L 1 1 4 German IV 3:0:3
Continued selected reading of significant German writing with critical and aesthetic evaluation. Also selected readings in philosophical and scientific subjects. Practice in conversation. Prerequisite: ML 113 or equivalent.

M L 1 1 5 Conversation and Composition* 3:0:3
Spoken German with particular attention devoted to idiomatic expressions; compositions with training in syntax and style. Prerequisite: ML 114 or equivalent.

M L 1 2 1 Scientific German I* 3:0:3
Introductory course designed for students who wish to acquire facility in translation of scientific material from German into English. Includes introduction to fundamentals of grammar, problems of syntax and idioms, with emphasis on scientific terminology. May not be offered in fulfillment of any language sequence or as a humanities elective. Prerequisite: ML 121 or equivalent.

M L 1 2 2 Scientific German II* 3:0:3
Continuation of ML 121. Reading material selected from periodical and technical journals covering several fields in science and engineering. May not be offered in fulfillment of any language sequence or as a humanities elective. Prerequisite: ML 121 or equivalent.

M L 2 1 3 German Drama from 1800 to Present* 3:0:3
Major 19th-century dramatists; including Hebbel, Kleist, Grillparzer, Hauptmann. Background, analysis, interpretation of German drama of 20th century. Lectures, readings and reports. Prerequisite: ML 114 or equivalent.

M L 2 1 4 Contemporary German Literature* 3:0:3
Study of 20th-century German writers and literary movements. Lectures, readings, reports. Prerequisite: ML 114 or equivalent.

M L 2 1 5 Goethe's Faust, Part I* 3:0:3
Background and genesis of Goethe's drama. Reading and
discussion of Part I, examining its aesthetic, moral, ethical values. Prerequisite: ML 114 or equivalent.

ML 216 Goethe's Faust, Part II* 3:0:3
Reading and discussion of Part II, examining its modern cultural implications. Consideration of Goethe's contribution to field of science. Prerequisite: ML 215.

ML 217-218 German Thought from Kant to Present I, II* each 3:0:3
Traces course of significant intellectual currents in writings of philosophers, scientists, poets, social critics. First semester discussion on period from Kant to Nietzsche, second semester on period from Nietzsche to present. Readings in German and English. Prerequisite: ML 114 or equivalent.

ML 220 German Civilization* 3:0:3
Cultural and political history of Germany with discussions of physical and political geography, art, music, religion, philosophy, education, the social and economic structures. Prerequisite: ML 114 or equivalent.

FRENCH

ML 131 French I: Foundation Course 3:0:3
For students who have had no previous training in French. Audiolingual emphasis on developing proficiency in reading, comprehension, speaking. Early practice in reading original French prose and representative poems.

ML 132 French II 3:0:3
Continuation of basic foundation provided by ML 131. Reading of modern French prose and poetry of intrinsic literary value. Prerequisite: ML 131 or equivalent.

ML 133 French III: Readings in French Literature Since 1800 3:0:3
Selected reading and discussion of significant works in prose, lyric poetry, drama to acquaint student with outstanding writers, ideas, movements in French literature. May be taken by students who have had secondary school training in French. Prerequisite: ML 132 or equivalent.

ML 134 French IV 3:0:3
Continuation of ML 133. Reading of mature prose in cultural, philosophical, scientific subjects. Practice in conversational French. Prerequisite: ML 133 or equivalent.

ML 135 Conversation and Composition* 3:0:3
Spoken French with particular attention to idiomatic expressions, composition with training in syntax and style. Prerequisite: ML 134 or equivalent.

ML 235-236 French Thought From Rabelais to Sartre I, II* each 3:0:3
Traces course of two major currents in French thought: liberalism and traditionalism. First semester discussion on Rabelais, Montaigne, Descartes, Pascal, Rousseau, Voltaire, the Encyclopedists. Second semester on Joseph de Maistre, Balzac, Michelet, Comte, Taine, Penan, Bergson, Sartre, Martin, Levi-Strauss. Readings in French and English. Prerequisite: ML 134 or equivalent.

ML 237 Contemporary French Literature* 3:0:3
 Examination of varied currents of 20th-century literature as exemplified in authors ranging from Proust to Camus, Sartre, the exponents of the nouveau roman. Lectures, readings, reports. Prerequisite: ML 134 or equivalent.

ML 238 French Civilization* 3:0:3
Cultural and political history of France and French community with discussion of physical and political geography, art, music, religion, philosophy, education, the social and economic structures. Prerequisite: ML 134 or equivalent.

RUSSIAN

ML 151 Russian I: Foundation Course* 3:0:3
For students who have had no previous training in Russian. Audiolingual emphasis on developing proficiency in reading, comprehension, speaking. Early practice in reading original Russian prose and representative poems.

ML 152 Russian II* 3:0:3
Continuation of basic foundation provided by ML 151. Reading of Russian prose and poetry of intrinsic literary value. Prerequisite: ML 151 or equivalent.

ML 153 Russian III: Readings in 19th-Century Russian Literature* 3:0:3
Selected reading and discussion of significant works in prose, lyric poetry, drama to acquaint student with outstanding writers, ideas, movements in Russian literature. Prerequisite: ML 152 or equivalent.

ML 154 Russian IV* 3:0:3
Continuation of ML 153. Reading of mature prose in cultural, philosophical, scientific subjects. Practice in conversational Russian. Prerequisite: ML 153 or equivalent.

ML 155-156 Contemporary Russian Literature and Civilization each 3:0:3
Readings in Russian prose and poetry. Simultaneous study of USSR's geographic, political, cultural status, to serve as appropriate background material. All readings in Russian. Prerequisite: ML 154 or equivalent.

SPANISH

ML 161 Spanish I: Foundation Course 3:0:3
For students who have had no previous training in Spanish. Audiolingual emphasis on developing proficiency in reading, comprehension, speaking. Early practice in reading original Spanish prose and representative poems.

ML 162 Spanish II 3:0:3
Continuation of basic foundation provided by ML 161. Reading of modern Spanish prose and poetry of intrinsic literary value. Prerequisite: ML 161 or equivalent.

ML 163 Spanish III: Readings in Spanish Literature Since 1800 3:0:3
Selected reading and discussion of significant works in prose, lyric poetry, drama to acquaint student with outstanding writers, ideas, movements in Spanish literature. May be taken by students who have had secondary school training in Spanish. Prerequisite: ML 162 or equivalent.

ML 164 Spanish IV 3:0:3
Continuation of ML 163. Reading of mature prose in cultural and philosophical subjects. Practice in conversational Spanish. Prerequisite: ML 163 or equivalent.

ML 265-266 Culture of Latin America I, II* each 3:0:3
Survey of intellectual and literary aspects of Hispanic-American civilization touching on historical, sociological, political, economic background material. Readings in Spanish. Discussion of contemporary scene and practice in speaking Spanish. Prerequisite: ML 164 or equivalent.

LITERATURE IN TRANSLATION

ML 311 Currents of Unrest in 20th Century: German Literature (in English translation)* 3:0:3
Study of some major writers of German-speaking countries
against turbulent political background of Europe in 20th century. Students study one complete work by each of the following novelists: Hermann Hesse, Franz Kafka, Thomas Mann, Heinrich Boll, Gunther Grass, Hermann Raitl. Course work directed toward understanding these men and their work within their own varying social and cultural settings. Students encouraged to pursue interests in individual authors.

ML 312 Currents of Unrest in 20th Century: French Literature (In English translation)  3:0:3
Study of modern French authors: Jean-Paul Sartre, Albert Camus, Samuel Beckett. Eugene Ionesco, Jean Genet. Course work includes one complete work of each writer. Students encouraged to pursue interests in individual authors.

ML 313 Currents of Unrest in 20th Century: Russian Literature (In English translation)  3:0:3
Study of modern Russian literature in post-revolutionary political and social setting. Course work based on works by Sholokhov, Pasternak, Solzhenitsyn. Students encouraged to pursue interests in individual authors.

ML 316 The Hebrew Bible*  3:0:3
A study of three parts of Hebrew Bible with emphasis on language of Bible and traditional modes of interpretation. Discussion of recent paleographic and archaeological materials.

ML 319 The Jewish Heritage*  3:0:3

LINGUISTICS

ML 381 Language and Society*  3:0:3

ML 382 Introduction to the Study of Language  3:0:3
Principles and methods of descriptive study of language. Survey of major linguistic theories. Development of writing. Typological diversity in world languages and the mechanisms of language change that give rise to linguistic variety. May be taken as humanities elective.

ML 383 Advanced Topics in Study of Language*  3:0:3

INTERDISCIPLINARY STUDIES

IS 140 Language and Communication  3:0:3
A study of types of language and modes of communication, including animal (bee, chimpanzee) and human communication, language development in children, and the languages of music, art, literature and engineering (the Brooklyn Bridge). Readings, films, group projects and reports, museum visits, expository and creative writing.

IS 141 The Self and Society  3:0:3
An exploration of the relationship between the individual and society, language as a vehicle of culture, cultural variety and the significance of cultural models (from Homer's Odyssey to Orwell's 1984 and O'Neill's proposed space colony). Readings, films, group projects and reports, museum visits, writing. Prerequisite: IS 140 or permission of instructor.

IS 145 The American, This New Man  3:0:3
An examination of the changing pattern of nationalism in the United States and the changing self-definition of the American in response to forces from within the country and from without—as found in literary, artistic and historical sources from the 17th century to the present.

IS 146 Brooklyn: History and Culture  3:0:3
An interdisciplinary exploration of the evolution of Brooklyn from a collection of aboriginal communities to a European colony and eventually an American city. Stressing social, political, economic and cultural factors, this course covers the physical growth, political evolution, economic development, transportation networks and cultural life of evolving Brooklyn.

GRADUATE COURSES

SCIENCE, TECHNICAL AND FINANCIAL WRITING AND JOURNALISM

JW 600 Introduction to Specialized Journalism  2%:0:3
A course designed to familiarize the student with the career opportunities available and the writing requirements demanded in these major fields of specialization: financial and business journalism, industrial and trade magazine journalism, medical journalism, industrial public relations and advertising, scientific and engineering writing. Students will be required to research and write articles in each of these areas.

JW 601 Style for the Professional Writer  2%:0:3
Designed to strengthen the student's command of usage, style, grammar, punctuation, precision, logical structure and color through intensive copyediting practice.

JW 602 Proposal Writing  2%:0:3
Solicited and unsolicited proposals in both the government and private sectors are covered. The different types of proposals are covered. Topics include writing and editing, ability to work as a team member and to cope under heavy pressure, knowledge of graphics and production and procedures in proposal writing. Emphasis on the elements of a typical proposal, such as statement of the problem, technical discussion, how the team will organize to perform the task, fiscal information, technical competency of the company to perform the task, key personnel, etc. The student will be required to prepare an outline and then to write a proposal on a specific topic worked out with the instructor as the major course assignment.

JW 603 Reporting on Science, Technology and Medicine  2%:0:3
Emphasis on spot-news reporting and the Sunday-supplement feature aimed at a general newspaper audience. The longer interpretative pieces done for this course will require personal and/or telephone interviews with recognized medical, scientific and engineering authorities in a given discipline. The stories, however, will be written in a popularized vein for a general audience. Course will consider how science writers develop feature articles, ideas and how they follow them through to publication. Students will be encouraged to submit the work they do in the course for publication.
JW 604 Graphics and Production Techniques 2½:0:3
An introduction to graphic design and production techniques and procedures for technical writers and editors, with emphasis on magazine layout and producing technical reports, manuals and proposals. Topics covered will include composition methods, copy preparation and processing, page makeup, mechanics, printing processes, magazine imposition. Course will be conducted in a workshop atmosphere.

JW 605 Lidel Law and Press Ethics 2½:0:3
Based on a study of some classic cases, this course will familiarize the student with the essentials of libel law necessary when writing for publication. Journalistic ethics and writer’s responsibilities to sources and readers are also considered.

JW 606 Oral Technical Presentations 2½:0:3
The factors that make an engineering or scientific talk or panel discussion not only informative but interesting to the listener from an audio-visual standpoint are well. Major considerations are content of the talk, the speaker’s demeanor, use of visuals (diagrams, delivery of the talk (intonation, enunciation, voice, posture, gestures, methods of presentation). Students will participate in speechmaking situations and in panel discussions covering a wide variety of technical subjects.

JW 607 Writing News for Radio and Television 2½:0:3
This course is designed to train students to write news for the electronic media. The focus will be on science and business news stories. The course will entail intensive practice in writing for radio and television, and will teach students accepted format and style of media news writing. The course will also acquaint students with the requirements and limitations of the media and how those must be taken into account in news writing. Students will use video and audio technology in the course.

JW 620 Financial and Business Reporting 2½:0:3
For students who intend to go into financial and business reporting or financial public relations, this course will be conducted as a workshop. Students will cover the business and financial scene as if they were reporting for a business periodical or the financial section of a newspaper. Hard business news reporting and interpretive pieces will be stressed in such areas as economic trends, marketing, corporate activities, the stock market, government regulations, industrial technology, labor-management relations, energy, industry and the environment and advertising. Course will familiarize the student with the corporate annual report, the investment company’s research report, stock analysis reports, the financial press release. Financial and business publications will be studied.

JW 621 Reporting and Editing for the Business Press 2½:0:3
The need exists on business and trade magazines—both technical and non-technical—for reporters and editors with solid journalistic skills and a knack for digging out facts. This course surveys the diverse editorial opportunities in business-press journalism and helps the student develop the necessary skills in writing, editing and interviewing that such publications demand. Among the assignments: writing short news stories, copy-editing (including the writing of heads and decks), rewriting weak copy for a magazine’s departments (new products, books and literature, case histories, news, company and personality profiles, etc.), short features describing plant layouts, machine operation, maintenance procedures and business conditions. Consideration will be given also to the longer feature article, often referred to as the roundup story. Since most specialized business (trade) magazines serve a particular field of industry (automotive, electronics, petrochemicals, etc.), many of the articles appearing in them are contributed by industry authorities. The course will emphasize the responsibility of the editor to cultivate good working relationships with such people to induce them to write.

JW 622 Writing Copy for Industrial Public Relations 2½:0:3
A workshop approach to doing public relations work for a corporation requiring both product and corporate publicity. Course covers the PR functions from the standpoint of both the in-house staffer and the account executive at the agency. Among the subjects taken up: publicity methods used to introduce a new product, writing the standard press release, preparation of the technical article dealing with a phase of the company’s expertise, writing and placement of case histories, arranging press conferences and plant tours, handling press inquiries, writing speeches. The course also considers the working relationship that develops between the PR agency and the in-house staff of the client in cases where companies utilize both services.

JW 623 Publications Management and Budgeting 2½:0:3
Setting up and managing a budget for a publication. This course deals with all phases of expenses (fixed and variable) incurred in the establishment and operation of both a corporation’s publications group and a business magazine’s editorial department: sources of income, salaries and fringe benefits, art costs, production costs (including printing), travel and entertainment, telephone, space rental, office supplies, temporary help and other expenses normally incurred by editorial departments. Budgeting for the business magazine will concentrate on five key elements, showing how they relate to the editorial department’s operation: editorial, mechanical, advertising, circulation, administration. Students will work on specific projects involving page budgets and dollar budgets.

JW 624 Writing Product-Information Copy 2½:0:3
Consideration of the mass of sales-promotional and technical catalogues, brochures, manuals, spec sheets, flyers and news releases that promote a company’s products. Emphasis will be on the approaches to writing such material. In addition to preparing copy for the longer product-promotion bulletin, students will be responsible for providing the text for a major catalogue or brochure promoting a given product or technology and based on raw data either provided by the instructor or gathered by students. Course will stress the need for product information of varying degrees of technical complexity to suit the technical competency of the prospective customer for whom the literature is intended.

JW 625 Advanced Medical Reporting 2½:0:3
Writing on medical and biological subjects, with emphasis on interviewing. Students will gather much of the information for their writing assignments from sources in the field and will prepare articles for the general press, semi-technical reports for pharmaceutical houses, articles for professional magazines, and sales and promotional literature for medical products.

JW 626 Medical Public Relations 2½:0:3
The special considerations, responsibilities and problems faced by public relations officials at medical research facilities, hospitals, medical schools, foundations and fund-raising organizations and pharmaceutical companies. Emphasis on writing medical and pharmaceutical press releases, brochures, film scripts, other in-house publications, speeches, press kits for press briefings. Visits to medical facilities to talk with public relations officials and research scientists.

JW 627 Writing Copy on Pharmaceuticals and Drugs 2½:0:3
Course is geared to preparing students for expanding opportunities in writing copy for pharmaceutical and drug com-
The purpose of the marketing report is to aid the preparation of an ad campaign, how to set up booths for industrial displays and exhibits, conducting the direct-mail campaign, the value and preparation of sales literature and an analysis of business publication advertising today. The roles of the company advertising manager and the agency's account executive and their interrelationship are delineated. Completion of a special project and several ad writing assignments will be required.

**JW 529 Writing the Marketing Report** 2 ½: 0: 3

The purpose of the marketing report is to aid the client in finding the best means to increase sales of a given product. It is also employed to present the findings of test-marketing programs and to make recommendations based on those findings. This course deals with the writing of reports based on intensive analysis of customer reaction to a given product. Students will acquire the basic skills needed to research, analyze and interpret raw data gathered in putting together their own reports. The importance of making intensive use of tabular data and graphs will be stressed. Case histories will be studied.

**JW 630 Basic Technical Report Writing I** 2 ½: 0: 3

Fundamentals of technical writing. Emphasis on organization, clarity and accuracy in writing abstracts, descriptions of processes and mechanisms, definitions, short technical correspondence, trip reports, technical sales letters, technical information sheets and troubleshooting reports. Study of related literary information-retrieval techniques and use of data banks for background and verification of technical information.

**JW 631 Basic Technical Report Writing II** 2 ½: 0: 3

The longer report forms: progress, evaluation, feasibility, investigation. Analysis of parts of text, including statement of problem, methods, conclusions, and use of graphic and tabular material. Emphasis on logical organizations and clarity. Introduction to editing, layout and production techniques.

**JW 632 Writing Technical Manuals** 2 ½: 0: 3

Intensive practice in preparing industrial and military technical instruction manuals covering all phases of operation and maintenance of various kinds of equipment. Training in how to write these documents according to government specifications. The compilation of technical information for the manual and its use in conjunction with extensive graphics and tabular material (such as troubleshooting charts) are emphasized in practical writing situations. Assembling of a parts list is covered. The writing of military training manuals is also included.

**JW 640 The Video Documentary** 2 ½: 0: 3

This course will provide students with an opportunity to write and produce video documentaries. The emphasis in the course will be on video materials used in industry, i.e., tapes used in training, sales and promotion. The course will be both a writing course and a production course. Since this course will involve large-scale projects, students should take it after JW 601, which will provide some background in video and media writing.

**JW 701 Special Project in Professional Writing** 2 ½: 0: 3

Students, working in conjunction with a faculty member, will pursue a course of independent study dealing with a special facet of professional writing. They will be expected to gather the bulk of their information firsthand, that is, from personal contact with their sources, in addition to conducting the usual literature search. The end result of this project will be an original, thought-provoking, interpretive report to be submitted to the department for faculty review and approval.

**JW 702 Special Topics in Journalism** 2 ½: 0: 3

This special topics course will be offered from time to time by faculty members, visiting scholars and professionals. The special titles and prerequisites will be announced prior to registration.

**ENGLISH AND HUMANISTIC STUDIES**

**HU 521 Seminar in Oral English** 3 0: 0

For speakers of English as a second language, practice in pronunciation, articulation, informal discussion and formal oral presentation; emphasis on discourse skills characteristic of the American university environment. Admission, as required by graduate departments or by student choice. Course may be taken more than once.

**HU 605 Report Writing** 2 ½: 0: 3


**HU 622 Seminar in Shakespeare** 2 ½: 0: 3

Art and artifice in construction and motivation of several major plays by Shakespeare. Discussion and research papers. Prerequisites: HU 211, HU 212, HU 222 or equivalent.

**HU 638 Seminar in American Thought** 2 ½: 0: 3

Basic American attitudes and concepts as revealed by cultural output—literature, films, periodicals, comics, art—with emphasis on development of American mythology. Prerequisites: HU 281, HU 282, HU 282 or equivalent.

**HU 652 Seminar in Philosophy of Science** 2 ½: 0: 3

Selected aspects of methodology, presuppositions, scope, goals of natural sciences. Relations between science and philosophy; relation of scientific knowledge to world of experience; status of logical and mathematical truth; nature of explanation; causality, determinism, induction; laws and theories; nature of meaning.

**HU 654 Seminar in Social and Political Philosophy** 2 ½: 0: 3

Analysis of central concepts of social and political thought (freedom, law, justice, rights, democracy, property, etc.), as illustrated in writings of historical and contemporary philosophers. Emphasis on various interpretations of these concepts found in currently influential and conflicting sociopolitical ideologies.

**HU 697 Seminar in English Language** 2 ½: 0: 3


**MODERN LANGUAGES**

**ML 611 German for Research** 2 ½: 0: 3

For students in all fields who need practice in translation of scientific writings from German into English. Enlargement of scientific vocabulary. Problems of syntax and idioms chare-
teristic of scientific German. Intended to prepare students for M.S. and Ph.D. language examinations. Prerequisite: one year of German or instructor’s permission.

**ML 655** Russian for Research I  
21/2:0:3
Introductory course designed for students who wish to acquire facility in translation of scientific material from Russian into English. Involves introduction to fundamentals of grammar, problems of syntax and idioms, with emphasis on scientific terminology. Does not aim at thorough formal knowledge of the language. May not be offered in fulfillment of language requirement.

**ML 656** Russian for Research II  
21/2:0:3
Continuation of ML 655. Reading material selected from periodical and technical journals covering the several fields of engineering and science. Prerequisite: ML 655 or equivalent.

**FACULTY**

**Donald Hockney**, Professor of Philosophy of Science and Head of Humanities and Communications  
B.A., McMaster University; Ph.D., Cornell University  
*Philosophy of science, philosophy of language*

**Victor Bobetsky**, Professor of Modern Languages  
B.S., M.A., Columbia University  
*German language and literature*

**Bernard Rechtschaffen**, Professor of Modern Languages  
B.S., M.A., Ph.D., New York University  
*Comparative literature, science and literature*

**Duane DeVries**, Associate Professor of English  
B.A., Kalamazoo College; M.A., Ph.D., Michigan State University  
*Dickens, nineteenth-century English novel, expository writing*

**Anne Eisenberg**, Associate Professor of Humanities and Communications  
B.A., Barnard College; M.A., University of Iowa; Ph.D., New York University  
*Linguistics, technical writing, reading*

**Carl Milcham**, Associate Professor of Philosophy  
B.A., M.A., University of Colorado  
*Philosophy of technology*

**Lowell L. Scheiner**, Associate Professor of Humanities and Communications  
B.A., City College of New York; M.A., Columbia University; M.S., Columbia University (Graduate School of Journalism)  
*Technical writing, journalism*

**Harley S. Thompson**, Associate Professor of English  
B.A., College of Wooster; Ph.D., Yale University  
*English Renaissance, Milton; classical literature*

**Wolhee Choe**, Assistant Professor of English  
B.A., Adelphi University; M.A., City University of New York  
*Nineteenth-century English literature, critical theory, English as a second language*

**Barbara Quint Gray**, Assistant Professor of Humanities and Communications  
B.A., The University of Michigan; M.A., Harvard University; Ph.D., New York University  
*Linguistics, expository writing*

**Peter Z. Grossman**, Assistant Professor of Humanities and Communications  
M.A., M.F.A., Columbia University  
*Business and financial journalism, creative writing, dramatic literature*

**Sylvia Kasey Marks**, Assistant Professor of English  
B.A., M.A., University of Michigan; Ph.D., Princeton University  
*Samuel Richardson, eighteenth-century English novel, public speaking*

**ADJUNCT FACULTY**

**Bill Abrams**, Adjunct Instructor of Communications  
B.A., Tufts University; M.A. (Journalism) and M.A. (Business), Columbia University

**Frank Allen**, Adjunct Instructor of Communications  
M.A., University of Oregon

**Sophia Balcoff**, Adjunct Instructor of English  
B.A., University of Pennsylvania; M.A. (TESOL), Columbia University; M.A. (English), Cambridge University  
*English as a second language*

**Charlotte Balfour**, Adjunct Instructor of English  
B.A., City College of New York

**Edward Bell**, Adjunct Instructor of Communications  
B.A., City College of New York

**Jerry E. Bishop**, Adjunct Instructor of Communications  
B.A., University of Texas

**Mona Fisk Bloom**, Adjunct Instructor of English  
B.A., Brooklyn College; M.A., University of Kansas

**Allen M. Cobrin**, Adjunct Instructor of Communications  
B.A., City College of New York; M.A., Columbia University

**Frederick Courtney**, Adjunct Instructor of Modern Languages  
B.A., Columbia College; M.A., University of Michigan; Ph.D., Columbia University

**Manning Dandridge, III**, Adjunct Instructor of English  
B.A., M.A., SUNY at Stony Brook

**Joseph Gibaldi**, B.A., City College of New York; M.A., City University of New York; Ph.D., New York University

**Joseph P. Granitto**, Adjunct Instructor of English  
B.S., Hofstra; M.A., University of Chicago

**Annette Henderson**, Adjunct Instructor of Communications  
B.A., Brown University
Barbara Horwitz, Adjunct Instructor of Communications
B.A., Barnard College; M.A., Brooklyn College; Ph.D., SUNY at Stony Brook

Eric Katz, Adjunct Instructor of Philosophy
B.A., Yale University; M.A., Boston University

Leonora Kuhn, Adjunct Instructor of English
B.A., Hinter College; M.A., University of Arizona

Jerome M. Leitner, Adjunct Professor of Communications
B.A., Brooklyn College; LL.B., New York University Law School

Linda Lerner, Adjunct Instructor of English
B.A., M.A., Brooklyn College

Suzanne Loebl, Adjunct Instructor of Communications
B.S., Institute Maurice Chimie, Brussels

Sarah McGregor, Adjunct Instructor of English
B.A., Kirkland College, M.A., Columbia University

Susan Mernit, Adjunct Instructor of English
B.A., Bard College; M.A., Ohio State University

Nanci Milstein, Adjunct Instructor of Art
B.A., M.A., SUNY at Binghamton

Alan M. Nadler, Adjunct Instructor of English
B.A., Queens College; M.A.T., University of Iowa; M.F.A., Columbia University

Hans Ostermann, Adjunct Instructor of Modern Languages
B.A., M.A., Hofstra University

Richard A. Parts, Adjunct Instructor of English
B.A., University of California at Davis; M.A., San Francisco State University; Ph.D., University of California at Berkeley

Sidney Reitman, Adjunct Instructor of Communications

Stephanie S. Rosenthal, Adjunct Instructor of English
B.A., Birmingham University

Julie Salamon, Adjunct Instructor of Communications
B.A., Tufts University; J.D., New York University School of Law

Colleen M. Sandford, Adjunct Instructor of English
B.A., Washburn University; M.A., Ph.D., University of Illinois

Valerie Sayers, Adjunct Instructor of English
B.A., Fordham University; M.F.A., Columbia University

Roberta L. Ventsias, Adjunct Instructor of English
B.A., M.F.A., Brooklyn College

Marsha Witten, Adjunct Instructor of Communications
B.A., Barnard College

Emeritus Faculty

John G. Cavanna, Professor Emeritus
Ph.D., University of Minnesota

Clifford Osborne, Professor Emeritus
M.A., University of Denver

Warrington Winters, Professor Emeritus
Ph.D., University of Minnesota
The Department of Industrial Engineering and Operations Research offers programs in the area of industrial engineering at the bachelor's, master's, engineer's, and doctoral levels.

The field of industrial engineering deals with the analysis, design and utilization of modern, large-scale systems, ranging from completely automated processing plants through urban systems—transportation, justice and health care, for example—to managerial systems composed solely of human beings. It concerns itself with those areas in which the systems approach, engineering knowledge and analytical techniques are applied directly to the most urgent problems of society.

As noted in a career statement by the Institute of Industrial Engineers: "Industrial engineers deal with people as well as things. They look at the 'big picture' of what makes society perform best—the right combination of human resources, natural resources and man-made structures and equipment. Industrial engineers bridge the gap between management and operations, dealing with and motivating people as well as determining what tools should be used and how they should be used."

The discipline is a rapidly developing professional field with opportunities in many diverse areas. For example, practitioners are called on to:

- Analyze and plan production schedules and inventories
- Devise ways of maximizing the effectiveness of hospitals and other health care facilities
- Diagnose and correct causes of poor quality in production
- Study the feasibility of equipment replacement
- Evaluate proposed traffic control procedures
- Locate new plants and design their physical layout
- Develop computer simulations of man-machine systems
- Study the effects of feedback and automation on society and industry

Industrial engineers apply engineering and operations research techniques to the analysis and solution of actual problems in industry, government and nonprofit service organizations. While there is considerable overlap of industrial engineering with operations research, a few differences may be noted. Operations researchers tend to emphasize analysis and prefer analytical models. The industrial engineer's primary task is to solve specific problems and to design new man-machine configurations. They make heavy use of the computer, frequently employing heuristic rather than analytic approaches.

Industrial engineers concern themselves with systems in which the mission is imprecisely specified, in which limited resources are available, or in which there is great variability in input and output demands. They are involved in decision-making in the face of incomplete information and conflicting objectives that frequently cannot be adequately defined, that are subjective, and that are difficult to quantify. They seek to allocate limited resources in an optimal manner. A unifying theme focusing this body of knowledge and methods into a coherent entity is the system point of view. The search for similarity among concepts, laws and models of different disciplines, the emphasis on the adaptation, integration and exploitation of existing techniques in areas other than their fields of origin, and, above all, a unique point of view dealing with relationships rather than with components—these characterize the orientation of industrial engineering.

Industrial engineers apply these techniques in a very wide range of organizations. There are industrial engineers in banks, hospitals, government, transportation and communications, construction, social service, facilities design, manufacturing, warehousing and information processing.

Many industrial engineers eventually move from the analysis and design of productive systems to other administration. While engineering and management are different fields of endeavor, both require the ability to make decisions based on valid information. The industrial engineer is especially trained in obtaining and evaluating such information.

In addition to the programs listed, students may be interested in offerings in Economic Systems, Operations Management and Operations Research, which are described elsewhere in this catalog.
UNDERGRADUATE PROGRAM

The undergraduate program leads to the degree of bachelor of science in industrial engineering, which is accredited by the Accreditation Board for Engineering and Technology. The program is built on the essential scientific and mathematical foundations underlying the field.

The undergraduate program requires 136 credit-hours of work, including mathematics, chemistry, physics, humanities, social science, required departmental courses and technical and free electives. The humanities, technical and free electives permit an extremely flexible program of study in which the student has the opportunity to pursue individual interests that build on the core requirements.

While other engineers work primarily toward the creation of better products, industrial engineers are also concerned with the economic and human effects of changing technology. The undergraduate curriculum therefore provides a strong background not only in engineering, mathematics and physical sciences, but also in economics and psychology. In addition, the industrial engineering courses emphasize the application of these disciplines in industry, government and service institutions such as hospitals, banks and schools. Industrial engineers are thus in a strategic position to bring about the best integration of people, materials, machines, time and money in any endeavor.

Graduate courses may be taken as electives by qualified juniors and seniors with at least a B average, who obtain their adviser's approval. If the total number of credits exceeds those required for the bachelor's degree, these graduate credits may be credited toward a graduate degree in accordance with current Polytechnic policy.

TRANSFER STUDENTS

Transfer students who have completed two years of study at a college of liberal arts and science or a community college, may ordinarily complete the requirements for the bachelor's degree in two additional years of study. Assuming that the student has completed 64 credits equivalent to MA 101-104, PH 101-103, CM 101-102, CM 111-112, CS 100, HU 101, HU 200, SS 104, SS 189, SS 251-252, plus 14 credits of acceptable courses, the student can complete the requirements shown.

EVENING STUDY

All courses for the industrial engineering program are available in the evening or late afternoon for the convenience of part-time students. A part-time student usually can finish the program in eight years, without summer work, by averaging eight and a half credits per semester. However, students can change the pace readily to suit their educational needs, provided they do not violate prerequisites and institute time limits.

SUGGESTED ELECTIVE SEQUENCES

Students often seek guidance in using the permitted electives to develop a meaningful sequence for concentration. Some suggested groupings from which the student may select electives are shown in the Operations Research section of this catalog; these are merely suggestions, not required sequences of study.

Requirements for the Degree of Bachelor of Science in Industrial Engineering

<table>
<thead>
<tr>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics: MA 101', MA 102', MA 103', MA 104', MA 223, MA 224</td>
</tr>
<tr>
<td>Science: CM 101, CM 102, CM 111, CM 112, CS 100', PH 101, PH 102,</td>
</tr>
<tr>
<td>Humanities: HU 101, HU 200', SS 104', SS 189, SS 251, SS 252</td>
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<tr>
<td>Physical Ed: PE 101, PE 102, PE 103, PE 104</td>
</tr>
<tr>
<td>Engineering: AM 101, AM 115, AM 121, EE 370, EE 374, MT 301</td>
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<tr>
<td>Management: MG 304</td>
</tr>
<tr>
<td>Major: IE 254, IE 300, IE 306, IE 311, IE 319, IE 321, IE 327, IE 328, IE 365, IE 380, IE 401', IE 402'</td>
</tr>
<tr>
<td>Electives: Chosen by student in consultation with departmental adviser</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

A typical program sequence is shown here covering eight semesters. Students may rearrange courses and increase or decrease load per semester to suit their educational needs, provided prerequisites are not violated. In particular, the actual number of elective and total credits in any given semester will vary by 1 or 2 credits because most electives are 3 credits.

See footnotes on following page.
# Typical Course of Study for the Degree of Bachelor of Science in Industrial Engineering

## Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>CS 100 Intro to Computer Progrng</td>
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<td>AM 101 Graphics</td>
<td>1 3 2</td>
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<tr>
<td>HU 101 College Composition</td>
<td>3 0 3</td>
<td>HU 200 Intro to Literature</td>
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<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
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<td>PH 102 Introductory Physics II</td>
<td>3 0 3</td>
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<td>SS 251 Micro-Economics</td>
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## Sophomore Year

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<th>No. Subject</th>
<th>Cl. Lab. Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM 115 Engineering Mechanics</td>
<td>4 0 4</td>
<td>AM 121 Mechanics of Materials</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 101 General Chemistry</td>
<td>2 0 2</td>
<td>CM 102 General Chemistry II</td>
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<td>CM 111 General Chemistry Lab I</td>
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<td>CM 112 General Chemistry Lab II</td>
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<td>IE 254 Intro to Industrial Engineering</td>
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<td>MA 103 Calculus III</td>
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<td>MA 104 Appl Differential Equ</td>
<td>3 0 3</td>
<td>MG 304 Accounting Fundamentals</td>
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<td>PH 103 Introductory Physics III</td>
<td>2 0 3</td>
<td>SS 104 Contemp. World Hist</td>
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<td>PE 103 Physical Education III</td>
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<td>16</td>
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## Junior Year

<table>
<thead>
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<th>Cl. Lab. Cr.</th>
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<tbody>
<tr>
<td>IE 206 Work Design &amp; Measurement</td>
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<td>IE 200 Engineering Economy</td>
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<td>IE 207 Operations Research I</td>
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<td>IE 208 Operations Research II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 203 Intro to Probability</td>
<td>3 0 3</td>
<td>IE 255 Human Factors in Engrg. Design</td>
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<tr>
<td>MT 301 Mech.Behav. of Materials</td>
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<td>IE 360 System Simulation</td>
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<tr>
<td>SS 109 Intro to Psychology</td>
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<td>Elective</td>
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## Senior Year

<table>
<thead>
<tr>
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<th>Cl. Lab. Cr.</th>
<th>No. Subject</th>
<th>Cl. Lab. Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 101 Prod. of Electrical Eng</td>
<td>3 0 3</td>
<td>EE 201 Facility Planning &amp; Design</td>
<td>3 0 3</td>
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<tr>
<td>EE 102 Instrument. Laboratory</td>
<td>3 0 3</td>
<td>IE 402 Project Laboratory II</td>
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<tr>
<td>IE 111 Stats. Quality Control</td>
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<tr>
<td>IE 210 Prodtn. Planning &amp; Control</td>
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<tr>
<td>Elective</td>
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<td>Elective</td>
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<tr>
<td>Total</td>
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Total credits required for graduation: 136
Typical Course of Study for Transfer Students

Junior Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl. Lab. Cr.</td>
<td>No.</td>
</tr>
<tr>
<td>AM 115</td>
<td>Engineering Mechanics</td>
<td>4 0 4</td>
<td>AM 121</td>
</tr>
<tr>
<td>IE 254</td>
<td>Intro to Industrial Engineering</td>
<td>3 0 3</td>
<td>IE 330</td>
</tr>
<tr>
<td>IE 306</td>
<td>Work Design &amp; Measurement</td>
<td>2½ 1½ 3</td>
<td>IE 326</td>
</tr>
<tr>
<td>IE 327</td>
<td>Operations Research I</td>
<td>3 0 3</td>
<td>MA 224</td>
</tr>
<tr>
<td>MA 233</td>
<td>Intro to Probability</td>
<td>3 0 3</td>
<td>MG 304</td>
</tr>
<tr>
<td></td>
<td>Elective²</td>
<td>2</td>
<td></td>
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Senior Year

<table>
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<tr>
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<th>No.</th>
<th>Subject</th>
<th>Cl. Lab. Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 370</td>
<td>Princ. of Electrical Engr</td>
<td>3 0 3</td>
<td>AM 101</td>
<td>Graphics</td>
<td>1 3 2</td>
</tr>
<tr>
<td>EE 374</td>
<td>Instrumentation Laboratory</td>
<td>0 3 1</td>
<td>IE 321</td>
<td>Facility Layout &amp; Location</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 311</td>
<td>Statist. Quality Control</td>
<td>3 0 3</td>
<td>IE 365</td>
<td>Human Factors in Engrg. Des.</td>
<td>2½ 1½ 3</td>
</tr>
<tr>
<td>IE 319</td>
<td>Product Planning &amp; Control</td>
<td>3 0 3</td>
<td>IE 380</td>
<td>System Simulation</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 401</td>
<td>Project Laboratory I*</td>
<td>1 3 2</td>
<td>IE 402</td>
<td>Project Laboratory II*</td>
<td>1 3 2</td>
</tr>
<tr>
<td>MT 301</td>
<td>Mech. Behav. of Materials</td>
<td>2 3 3</td>
<td>Electives²</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electives²</td>
<td>3</td>
<td></td>
<td></td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

See four-year program for notes. Total credits required for graduation: 136

MANUFACTURING ENGINEERING OPTION

In its beginning, the industrial engineering profession was devoted largely to manufacturing operations. Over the years, industrial engineers have been called upon to broaden their expertise to include a much wider range of applications, from hospital management to banking information systems. The consequent broadening of industrial engineering education led necessarily to a relative de-emphasis of manufacturing engineering.

But today, more than ever before, manufacturing enterprises must operate with heightened efficiency and precision to compete in the international marketplace. In doing its share to help American industry, Polytechnic has developed an option to re-emphasize manufacturing in its industrial engineering programs.

This manufacturing engineering option was prepared by an interdisciplinary committee, aided by a select industrial advisory committee and an extensive national survey. The option is designed to educate the student in productivity, computer-aided design and computer-aided manufacturing (CAD/CAM), robotics, factory automation and computer-integrated manufacturing (CIM).

Requirements for the Degree of Bachelor of Science in Industrial Engineering
(Manufacturing Engineering Option)

<table>
<thead>
<tr>
<th>Mathematics: MA 101', MA 102', MA 103', MA 104', MA 223, MA 224</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science: CM 101, CM 102, CM 111, CM 112, CS 100', PH 101, PH 102, PH 103</td>
<td>18</td>
</tr>
<tr>
<td>Humanites: HU 101, HU 200', SS 104', SS 189, SS 251, SS 252</td>
<td>18</td>
</tr>
<tr>
<td>Management: MG 304</td>
<td>3</td>
</tr>
<tr>
<td>Physical Ed.: PE 101, PE 102, PE 103, PE 104</td>
<td>0</td>
</tr>
<tr>
<td>Other Engrg: AM 101, AM 115, AM 121, AM 301, AM 302, AM 331, AM 332, AM 337, MT 301, MT 407, MT 417</td>
<td>33</td>
</tr>
<tr>
<td>Electives² Chosen by student in consultation with departmental adviser</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>136</td>
</tr>
</tbody>
</table>
### Typical Course of Study for the Degree of Bachelor of Science in Industrial Engineering (Manufacturing Engineering Option)

A typical program sequence covering eight semesters is shown below. Students may rearrange courses and increase or decrease load per semester to suit their educational needs, provided prerequisites are not violated. In particular, the actual number of elective and total credits in any given semester will vary by 1 or 2 credits because most electives are 3 credits.

<table>
<thead>
<tr>
<th>Freshman Year No. Subject</th>
<th>Hours/Week</th>
<th>Second Semester No. Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman Year</td>
<td>Hours/Week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Semester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>CS 103 Intro. to Computer Prog.</td>
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</tr>
<tr>
<td>HU 131 College Composition</td>
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<td>3</td>
</tr>
<tr>
<td>MA 131 Calculus I</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SS 251 Micro-Economics</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 101 Physical Education</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td></td>
<td>16</td>
</tr>
</tbody>
</table>

| Sophomore Year            |            |                |            |
| AM 115 Engineering Mechanics | 4 | 0 | 4 | AM 121 Mechanics of Materials | 3 | 0 | 3 |
| CM 101 General Chemistry I | 2½ | 0 | 2½ | CM 102 General Chemistry II | 2½ | 0 | 2½ |
| CM 111 General Chemistry Lab. | 0 | 1½ | ½ | CM 112 General Chemistry Lab. II | 0 | 1½ | ½ |
| IE 254 Intro. to Industrial Engineering | 3 | 0 | 3 | MG 304 Accounting Fundamentals | 3 | 0 | 3 |
| MA 104 Appl. Differential Equ. | 3 | 0 | 3 | MA 103 Calculus III | 3 | 0 | 3 |
| PH 103 Introductory Physics III | 2½ | 1½ | 3 | SS 104 Contemporary World Hist. | 3 | 0 | 3 |
| PE 103 Physical Education III | 0 | 2 | 0 | MT 407 Transport Meth. in Met. | 3 | 0 | 3 |
|                           | 16         |                | 18         |

| Junior Year               |            |                |            |
| MT 301 Mech. Behav. Mad. | 2 | 3 | 3 | IE 340 Manufacturing Process | 3 | 0 | 3 |
| IE 327 Operations Research | 3 | 0 | 3 | IE 328 Operation Research II | 3 | 0 | 3 |
| SS 189 Intro. to Psychology | 3 | 0 | 3 | MA 224 Intro. to Math. Statistics | 3 | 0 | 3 |
| MA 223 Intro. to Probability | 3 | 0 | 3 | AM 331 Computer Aided Design | 3 | 0 | 3 |
| AM 301 Synthesis of Mech. Syst. | 3 | 0 | 3 | AM 302 Anal. & Des. of Mach. Ei | 3 | 0 | 3 |
|                           | 18         |                |            |

| Senior Year               |            |                |            |
| IE 306 Work Design & Measurement | 2½ | 1½ | 3 | IE 300 Engineering Economy | 3 | 0 | 3 |
| IE 311 State Quality Control | 3 | 0 | 3 | IE 321 Facility Planning & Design | 3 | 0 | 3 |
| IE 319 Production Planning & Control | 3 | 0 | 3 | IE 402 Project Laboratory II | 1 | 3 | 2 |
| IE 401 Project Laboratory II | 1 | 3 | 2 | AM 337 Introduction to Robotics | 3 | 0 | 3 |
| MT 417 Welding Eng         | 3 | 0 | 3 | Electives | 7 |  |
| AM 332 Comp. Graphics      | 2 | 3 | 3 |                           | 18 |

Total credits required for graduation: 136

Footnotes 1, 3 and 4: See standard program footnotes.

2 Electives will consist of 6 credits of Humanities/Social Sciences and 7 credits of free electives, all requiring the adviser's approval.
GRADUATE STUDY

The department offers graduate programs in industrial engineering leading to the degrees of master of science, master of engineering, and doctor of philosophy.

Students may specialize in such areas as information science, system simulation, quality control, experimental design, man-machine systems, social systems dynamics, production engineering, production and inventory models, reliability and maintainability. Certificate programs are available for more limited graduate study in specialized topics.

Graduate students come with diverse academic training. Many professionals in this area of specialization receive the major part of their training at the graduate level. One ingredient common to our students is a desire to develop techniques for problem-solving and decision-making in a technological world.

MASTER OF SCIENCE DEGREE

The general requirements for the master of science degree are stated in this catalog under “Degree Requirements.” Detailed requirements for this degree are shown below.

Admission to the master of science program requires a bachelor’s degree in an engineering discipline, from an accredited institution, with a superior undergraduate academic record. Students not meeting all these requirements will be considered for admission on an individual basis, and may be admitted subject to the completion of appropriate undergraduate courses to remove deficiencies in preparation.

A knowledge of computer programming in a high level language, such as FORTRAN or PUI, is assumed.

Applications should be made to the department with industrial engineering indicated as the area of specialization.

Students are encouraged to seek waivers for all required courses in which they can demonstrate competence, so that they can use their time most effectively.

Requirements for the Degree of Master of Science in Industrial Engineering

A. Basic Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>IE 600</td>
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<td>IE 606</td>
<td>Work Design &amp; Measurement</td>
</tr>
<tr>
<td>MA 551</td>
<td>Elements of Probability</td>
</tr>
<tr>
<td>IE 608</td>
<td>Statistics</td>
</tr>
</tbody>
</table>

B. Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>IE 611</td>
<td>Statistical Quality Control</td>
</tr>
<tr>
<td>IE 619</td>
<td>Production Planning &amp; Control</td>
</tr>
<tr>
<td>IE 621</td>
<td>Facility Planning &amp; Design</td>
</tr>
</tbody>
</table>

C. Major Electives: (Select four courses)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 614</td>
<td>Model of Social Systems</td>
</tr>
<tr>
<td>IE 680</td>
<td>System Simulation I</td>
</tr>
<tr>
<td>IE 846</td>
<td>Urban Systems Analysis</td>
</tr>
<tr>
<td>IE 765</td>
<td>Human Factors in Engng. Design</td>
</tr>
<tr>
<td>IE 775</td>
<td>Industrial Safety Engineering</td>
</tr>
<tr>
<td>IE 776</td>
<td>Manufacturing Resource Planning</td>
</tr>
<tr>
<td>IE 778</td>
<td>Advanced Production Planning</td>
</tr>
<tr>
<td>IE 777</td>
<td>Manufacturing Improvement Curves</td>
</tr>
<tr>
<td>IE 779</td>
<td>Advanced Work Systems Design</td>
</tr>
<tr>
<td>IE 852</td>
<td>Applied Regression &amp; ANOVA</td>
</tr>
<tr>
<td>IE 853</td>
<td>Design of Experiments</td>
</tr>
</tbody>
</table>

D. Other Relevant Electives

Minimum total: 36 units

ENGINEER DEGREE

The degree of engineer in industrial engineering is a professional degree intended for engineers who desire to advance their professional development and training beyond the master’s level but without the original research that is required of doctoral students. The general requirements for the engineer degree are stated in this catalog under “Degree Requirements.” Detailed requirements for this degree are given here.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
</tr>
<tr>
<td>IE 606</td>
<td>Work Design &amp; Measurement</td>
</tr>
<tr>
<td>MA 551</td>
<td>Elements of Probability</td>
</tr>
<tr>
<td>IE 608</td>
<td>Statistics</td>
</tr>
</tbody>
</table>

1 All group A courses are required unless they are specifically waived by the advisor because the student either (a) has taken an equivalent undergraduate or graduate course, or (b) passes a validation examination for the course. Up to three group A courses actually taken may be credited toward the degree requirements, if more than three must be taken, the degree requirements will be increased accordingly.

2 Only one of each bracketed set of courses will be counted in the group in which it is listed; the other courses may be counted under group D.

3 Group D electives are to be chosen with the advisor’s approval to bring the total units to 36 plus any excess of group A courses beyond 9 units. They may include thesis, additional courses from groups B and C, or other graduate courses in this or other disciplines.

Many students are interested in taking management electives. Most MG courses will be approved. However, because of substantial overlap with IE courses, no credit will be given for MG 630, MG 632, or MG 635.

4 Certain introductory courses will be waived if the student takes specified advanced courses, for which full credit will be given: For IE 627, IE 631 and IE 632, for IE 628, IE 650.
Admission to the engineer degree program assumes possession of a master's degree substantially equivalent to the Polytechnic M.S. in I.E. The engineer degree requires a minimum of 72 units beyond the bachelor's degree or 36 units beyond the master's degree, including at least 6 units of a design project. On completion of the design project, the candidate will be required to make a final oral presentation before a faculty committee. The project requirement may be waived by the guidance committee for professionally mature candidates who have previously completed work in their major area that is judged to be of exceptional caliber and for those students who have completed a suitable master's thesis or project.

Requirements for the Degree of Engineer in Industrial Engineering

The student, with the adviser, will work out an approved program of study, having at least 36 units, including the following (groups A, B, C, and D refer to M.S. in I.E. requirements):

A. All group A courses (No credit)
B/C. All group B and C courses; only one of each bracketed set is required. No more than 7 of these courses may be credited toward the 36 units.
D. Any group E courses taken for the M.S. under group D, will reduce group E requirements and increase group G.
E. Advanced Major Electives 9 units
Select 3 of the following:
- IE 612 Advanced Quality Control
- IE 615 Social & Industrial Dynamics
- IE 618 Inventory Models
- IE 631 Linear Programming
- IE 650 Queueing Systems I
- IE 778 Advanced Production Planning
- IE 779 Advanced Work Systems Design
F. Project: IE 998 (units to be waived by adviser) 6-12 units
G. Other relevant electives 0-21 units

Minimum total 36 units

DOCTOR OF PHILOSOPHY DEGREE

The department offers a program leading to the degree of doctor in philosophy in industrial engineering. The general Polytechnic requirements for the doctor of philosophy degree are stated in this catalog under "Degree Requirements." Specific requirements for the doctoral program may be found in the department's doctoral brochure.

Entrance to a doctoral program is contingent upon passing the program's qualifying examination. This will consist of the Part I preliminary written examination and the Part II major field written examination; an oral examination may also be required. An examination in one foreign language is required, ordinarily French, German, or Russian.

The doctoral program requires a minimum of 90 units beyond the bachelor's degree, including a minimum of 24 units of dissertation, no more than 30 units of dissertation may be counted in the minimum total. After passing the written qualifying examination, the candidate will select a thesis adviser and prepare a formal proposal for the dissertation research. A thesis committee will be appointed to judge the merit of the proposed research. After approval of this proposal, the doctoral candidate shall register for research. On completion of the dissertation, the candidate must pass an examination in its defense.

CERTIFICATE PROGRAMS

The department offers certificate programs designed for the professional with work experience. A certificate program requires five courses, which are selected in line with the needs of the individual. Applicants for a certificate program must hold a bachelor's degree. On completion of the sequence with a B average or better, the individual is issued a certificate. Students who choose to work toward a master's degree are able to apply all courses taken toward a certificate on admission to the degree program. Additional information may be obtained from the department.

The certificate programs offered are:

Industrial Engineering
- IE 611 Statistical Quality Control
- IE 619 Production Planning & Control
- IE 650 Queueing Systems I
- IE 778 Advanced Production Planning
- IE 779 Advanced Work System Design

Quality Control & Reliability
- MA 561 Probability
- IE 608 Statistics
- IE 611 Statistical Quality Control
- IE 686 Component Reliability
- IE 612 Advanced Quality Control
- IE 685 System Reliability
- YY XXX Approved Elective

Production & Inventory Control
- IE 618 Inventory Models
- IE 619 Production Planning & Control
- IE 776 Manufacturing Resource Planning
- IE 671 Business & Economic Forecasting
- IE 680 System Simulation I
- IE 778 Advanced Production Planning
- YY XXX Approved Elective
UNDERGRADUATE COURSES

Note: Junior or senior standing is required for all undergraduate IE courses except IE 254.

IE 254 Introduction to Industrial Engineering 3:0:3
Survey course introducing scope of industrial management to engineers, presenting broad view of planning, organization, direction and control of industrial enterprises.

IE 300 Engineering Economy 3:0:3

IE 306 Work Design and Measurement 2.5:1:0:3
Principles and techniques of designing work methods and work simplification programs. Theory and techniques of work measurement, including time study, work sampling and standard data systems. Laboratory sessions in methods analysis, rating, work allowances and stopwatch time study.

IE 311 Statistical Quality Control 3:0:3
Process control concepts; concepts of statistical stability; operational randomness, control charts for variables and attributes, production control, design and analysis of attributes sampling plans, process capability of producer's and consumer's risks, AAT, AQL, and LQ of sampling plans, military sampling plans. Introduction to variable sampling plans. Prerequisite: MA 224.

IE 314 Modeling of Social Systems 3:0:3
Social systems viewed as interrelated positive and negative feedback loops whose behavior is governed by structure, amplification and delays. Using the DYNAMO language, students prepare, analyze and structure several models in ecology, management, economics or related areas individually chosen. Prerequisites: knowledge of calculus and computer programming.

IE 316 Commercial Data Processing System Design* 2:3:3
Applications of unit record equipment and computers in system design, including order writing, billing, accounts receivable, inventory control, payroll and labor accounting, accounts payable, general ledger, case studies. Laboratory use of data processing equipment. Prerequisite: knowledge of computer programming.

IE 319 Production Planning and Control 3:0:3
Analytical techniques for designing and operating production systems. Assembly-line balancing, job sequencing, inventory control, project planning with PERT and CPM. Applications of linear programming algorithms to shop loading and production scheduling of single and multiple products. Prerequisite: IE 327.

IE 320 Project Planning and Control 3:0:3
Network planning techniques for project management and resource allocation. Emphasis on PERT, CPM, and probability generalized networks. Heuristic models for multi-project scheduling and resource leveling. Other topics include network development, computer adaptation, progress reporting and project monitoring. Prerequisite: knowledge of computer programming.

IE 321 Facility Planning and Design 3:0:3
Development of quantitative models for analysis of facility layout and location problems. Solutions by both mathematical optimization and heuristic algorithms. Locations of single and multiple facilities in existing and new layout design. Other topics include computerized layout planning, materials handling systems, evaluation and improvement of facility productivity. Prerequisites: IE 306 and IE 327.

IE 324 Computers in Operational Analysis* 1:3:2
Cases involving problems in forecasting, inventory, scheduling, line balancing, maintenance, queuing, Markov chains, simulation, linear and integer programming, and materials requirement planning. Students may write their own computer programs or use existing packages to analyze the cases and design improved alternatives. Use of UNIX is encouraged. Written reports required. Prerequisites: IE 327 and IE 328.

IE 327 Operations Research I 3:0:3

IE 328 Operations Research II 3:0:3
Mathematical models for solving decision problems of stochastic nature. Queuing, Markov processes, inventory models, reliability, probabilistic dynamic programming. Prerequisites: IE 327 and MA 223.

IE 340 Financial Management 3:0:3
Financial concepts and techniques. Application of mathematical models to financial decisions. Prerequisites: MA 112, MA 228, and MA 327.

IE 346 Operations Research Applications to Developing Countries 3:0:3
Principles of operations research, management science, and decision making to developing countries. Application of mathematical models to social, economic, political, and educational problems of developing countries. Prerequisites: IE 327, IE 328 and junior standing.

IE 350 Human Resource Development in Developing Countries 3:0:3
Spectrum of technology-related manpower needs in less-developed countries: education of engineers, technicians and skilled mechanics. Using foreign personnel, foreign schools, "brain-drain" problems. Economic consequences. Comparisons of education systems of Western, Eastern and developing countries. Design of curricula to suit national needs. Role of technical assistance programs. Forecasting of human resource needs. Prerequisite: knowledge of computer programming.

Also listed under SS 338
IE 365 Human Factors in Engineering Design 2:1:1:3
Study of research techniques that yield information important in man-machine systems design. Man's learning, problem-solving, physiological and information processing capacities; performance under various environmental conditions. Prerequisite: SS 189

IE 375 Industrial Safety Engineering* 3:0:3
Analysis and design of industrial accident prevention, control and management systems. Effect of OSHA. Workman's Compensation and environmental factors in implementing safety programs. Project work involves safety inspection, detection and control of hazards.

IE 376 Manufacturing Resource Planning* 3:0:3
Quantitative models for analysis of production and inventory management systems. Topics covered include bill of material structures, time-phased parts requirements, shop loading and capacity constraints, priority planning and control, and schedule regeneration. Development of computer-based MRP systems. Prerequisites: IE 319, or permission of instructor, and knowledge of computer programming.

IE 377 Manufacturing Improvement Curves* 3:0:3
Development of learning-curve theory, analysis of various improvement curve models and estimation of parameters. Applications of improvement curves are incorporated in evaluating work standards, wage incentives, training and labor turnover cost, inventory control, price policy and production schedules. Prerequisite: IE 306.

IE 380 System Simulation 3:0:3
Modeling and simulation of discrete stochastic systems. Generation of pseudo-random numbers, variables from discrete, continuous, theoretical and empirical distributions. Extensive study of SIMSCRIPT, introduction to other languages. Students program, code and run several simulation models. Prerequisite: knowledge of computer programming.

IE 381-392 Selected Topics in Industrial Engineering and Operations Research I, II, each 3 credits
Areas not covered in other courses. Specific topics vary according to instructor, who may be a visiting professor. Topics and prerequisites announced during term prior to offering.

IE 393-394 Guided Studies in Industrial Engineering and Operations Research I, II, each 3 credits
Individual reading of specialized papers and current literature in specialized areas of study, guided by faculty member. Prerequisite: approval of advisor, instructor and department chairman.

IE 396 Industrial Engineering Internship* credit arranged
Supervised, creative engineering experience of at least two months' duration culminating in written and oral report presented to industrial and faculty supervisors. Faculty visits and conferences during internship. Arrangements to be made prior to beginning internship experience. Prerequisite: completion of junior year and departmental approval.

IE 399 Senior Honors Work in Industrial Engineering and Operations Research 2:0:3 credit arranged
Independent work undertaken by qualified honors students in industrial engineering or operations research under faculty guidance. Prerequisites: senior standing and advisor's approval.

IE 401-402 Project Laboratory I, II 1:3:2
IE 401—credit arranged
Independent project combining elements of theory, experimentation, design and construction used to teach methods of approach, design of experiments, modeling, validation and utilization of results which are common to undertaking of project development. Student-faculty seminars discuss individual projects to encourage students' exchange of ideas and methods, and to enhance each student's abilities in oral and written communication in engineering endeavors. Prerequisite: senior standing.

GRADUATE COURSES

IE 600 Engineering Economy 2:0:3
Economic and financial considerations in engineering decisions. Decision criteria under certainty, risk, uncertainty. Cost concepts, financial calculations, capital sources, accounting data, depreciation. Comparison of alternatives by annual cost, present worth and discounted cash flow methods. Minimum cost and maximum profit determination, replacement and economic life, breakeven analysis, effect of taxes, intangible factors. (Not open to students who have taken IE 300.)

IE 601 Introduction to Digital Computing 2:0:3
First course in computing, concentrating on analysis of problems for computer solution. Organization and characteristics of computers: structure and properties of algorithms and programs. Flow charting, debugging and verification, documentation. Number systems, data representation, numerical error analysis. FORTRAN IV language used. (Not open to students who have taken CS 100 or equivalent.)

Also listed under CS 531

IE 605 Work Design and Measurement 2:1:3
Principles and techniques of designing work methods and work simplification programs. Theory and techniques of work measurement, including time study, work sampling and standard data systems. Laboratory sessions in methods analysis, rating, work allowances and stopwatch time study. (Not open to students who have taken IE 306.)

IE 608 Statistics 2:0:3
Estimation, confidence limits, tests of hypothesis, regression analysis. Applications to engineering problems. Use of BMD and SPSS program packages. (Not open to students who have taken MA 224.) Prerequisite: MA 561.

Also listed under MA 562

IE 611 Statistical Quality Control 2:1:3
Process control: concept of statistical stability—operational randomness, control charts for variables and attributes. Product control: design and analysis of attributes sampling plans, concept of producer's and consumer's risks, AQL, AOQL, and LQ of sampling plans, military sampling plans. Introduction to variables sampling plans. (Not open to students who have taken IE 311.) Prerequisite: IE 606.

IE 612 Advanced Quality Control* 2:0:3
Continuation of IE 611. Theoretical basis of variable sampling plans. Emphasis on recently developed techniques: cumulative sum charts, theory of runs, evolutionary operations, nonnormal variables sampling plans, treatment of outliers in industrial data. Prerequisite: IE 611.
IE 614 Modeling of Social Systems I
2½:0:3
Social systems viewed as interrelated positive and negative feedback loops whose behavior is governed by structure, amplification and delays. Using the DYNAMO language, students prepare, analyze and restructure several models in ecology, management, economics or related areas individually chosen. (Not open to students who have taken IE 314.) Prerequisites: knowledge of calculus and computer programming.

IE 615 Modelling of Social Systems II
2½:0:3
Continuation of IE 614, with greater emphasis on underlying theory. More complex systems are analyzed, and control algorithms are designed and tested to improve performance. Prerequisite: IE 614.

IE 618 Inventory Models
2½:0:3
Study of inventory systems. Deterministic and probabilistic models. Fixed versus variable reorder intervals. Dynamic and multistage models. Statistical forecasting of demands and lead times. Control of dynamic inventory systems with lead times. Prerequisites: MA 561 and either IE 627 or IE 631.

IE 619 Production Planning and Control
2½:0:3
Analytical techniques for designing and operating production systems Assembly-line balancing, job sequencing, inventory control, project planning with PERT and CPM. Applications of linear programming algorithms to shop loading and production scheduling of single and multiple products. (Not open to students who have taken IE 319.) Prerequisite: IE 627 or IE 631.

IE 620 Project Planning and Control
2½:0:3
Network-planning techniques for project management and resource allocation. Emphasis on PERT, CPM, and probabilistic generalization of networks. Heuristic models for multi-project scheduling and resource leveling. Other topics include network development, computer adaptation, progress reports and project monitoring. (Not open to students who have taken IE 320.) Prerequisite: knowledge of computer programming. Also listed under MG 810.

IE 621 Facility Planning and Design
2½:0:3
Development of quantitative models for analysis of facility layout and location problems. Solutions by both mathematical and optimization and heuristic algorithms. Location of single and multiple facilities in existing and new layout design. Other topics include computerized layout planning, materials handling systems, evaluation and improvement of facility productivity. (Not open to students who have taken IE 321.) Prerequisites: IE 606 and either IE 627 or IE 631.

IE 624 Computer-Augmented Case Studies in Management Science
2½:0:3
Cases involving problems in forecasting, inventory, scheduling, line balancing, maintenance, queuing, Markov chains, simulation, linear and integer programming, and materials requirement planning. Students may write their own computer programs or use existing packages to analyze the cases and design improved alternatives. Use of UNIX is encouraged. Written reports required. (Not open to students who have taken IE 324.) Prerequisites: IE 627 and IE 628.

IE 627 Operations Research: Deterministic Models
2½:0:3
Development of mathematical models for solving decision problems of deterministic nature. Classical optimization, Lagrange multipliers, linear programming, transportation method, network procedures and games. Dynamic programming (Not open to students who have taken IE 327 or equivalent.) Prerequisite: Calculus.

IE 628 Operations Research: Stochastic Models
2½:0:3
Mathematical models for solving decision problems of stochastic nature. Queuing, Markov processes, inventory models, reliability, probabilistic dynamic programming. IE 628 and IE 627 constitute standard one-year survey course in operations research. (Not open to students who have taken IE 328 or equivalent.) Prerequisite: MA 611.

IE 631 Linear Programming
2½:0:3

IE 632 Nonlinear Programming
2½:0:3

IE 633 Integer Programming
2½:0:3
Solution techniques for integer and mixed-integer linear programming problems. Cutting plane methods, zero-one programming, branch and bound methods. Surrogate constraints. Quadratic programming. Applications to combinatorial analysis. Prerequisite: IE 631. Also listed under MA 814.

IE 634 Dynamic Programming
2½:0:3

IE 635 Advanced Linear Programming
2½:0:3

IE 636 Network Flows and Application
2½:0:3

IE 645 Productivity Management
2½:0:3
Modern approaches to productivity measurement, evaluation, planning and improvement in both manufacturing and service industries. Participants will develop productivity models for various types of organizations. Prerequisite: Graduate standing or permission of instructor. Also listed under MG 645.

IE 650 Queuing Systems I
2½:0:3
Development of elements of queuing and loss theory. Single and multiple server, Markovian and non Markovian arrival and service time distributions, various queue disciplines. Applications to inventory control, maintenance, transportation, communication, Model building and basic solution techniques.
stressed rather than formal theoretical development. Prerequisite: IE 659.

IE 651 Queuing Systems II 2½:0:3
Applications of queuing theory with emphasis on communications and vehicular traffic. Customer behavior, switching networks, overflow traffic, alternate routing, feedback, priorities, control. Formulation of standards based on cost-benefit viewpoint. Prerequisite: IE 650 or MA 815.

IE 654 Microeconomic Models 2½:0:3
Utility theory and decision-making under risk and uncertainty. Demand analysis and pricing in classical theory of the firm under various economic environments. Production functions. Linear programming and the firm. Analysis of short-run costs. Capital investment and analysis under capital rationing: deterministic and stochastic models. Prerequisites: IE 627 or MG 650 or permission of instructor, and MA 561.

IE 656 Macroeconomic Models 2½:0:3
Measures of economic activity, national income accounting and GNP. Input-output analysis, Leontief's static model, inter-industry relationships, applications to regional planning, economic forecasting and environmental problems. Dynamic models and growth models of national economy. Portfolio selection. Prerequisites: IE 608 and IE 627.

IE 671 Business and Economic Forecasting 2½:0:3
Forecasting for managerial decision control. Statistical vs. judgmental methods. Smoothing and analyses of trends, seasonal factors, cycles and random variations. Econometric forecasting. Economic indicators and sources of information. Applications to the national economy, industry sales, corporate profits, financial institutions, government expenditures, etc. Prerequisite: IE 608.

Also listed under MG 671

IE 673 Time Series: Forecasting and Control 2½:0:3

IE 674 Econometric Models and Methods* 2½:0:3
Single equation estimation vs. simultaneous-equation systems estimation. Regression techniques, instrumental and lagged variables. Problems of identification in simultaneous-equation methods. Two-stage, three-stage and limited information estimation. Applications to macroeconomic models, economic system structural analysis, short-term and long-term forecasting, etc. Prerequisite: IE 608.

Also listed under SS 713

IE 680 System Simulation I 2½:0:3
Modeling and simulation of discrete stochastic systems. Generation of pseudo-random numbers, variates from discrete, continuous, theoretical and empirical distributions. Extensive study of SIMSCRIPT, introduction to other languages. Students program, code and run several simulation models. (Not open to students who have taken IE 380.) Prerequisite: Knowledge of computer programming.

IE 681 System Simulation II* 2½:0:3
Advanced concepts of discrete simulation. Statistical aspects of simulation design, run length, efficiency. Methods for generation of nonuniform random variates, including probability, integral transform, rejection, composition techniques. Monte Carlo variance reducing techniques, including importance sampling, control variates and antithetic variates. Application to physical problems. Prerequisites: IE 608 and IE 680.

IE 685 System Reliability* 2½:0:3
Structural reliability, redundancy, bounds on reliability of complex systems. Repairable systems: Markov models, maintainability and availability. Optimization of spare parts inventories, inspection intervals and replacement times. Failure models: accumulated shocks and stress-strength-time. Marginal failure dependent failures. Prerequisite: EL 531 or MA 561 or equivalent.

Also listed under EL 617

IE 686 Component Reliability* 2½:0:3
Failure models for industrial components: exponential, Weibull, lognormal, gamma, Gumbel and other distributions. Failure and hazard rates, graphical probability plots and maximum-likelihood parameter estimation and testing. Sampling plans based on life tests and accelerated life tests. Serial and parallel analysis on components reliability. Prerequisite: EL 531 or MA 561 or equivalent.

Also listed under EL 618

IE 716 Commercial Data Processing System Design 2½:0:3
Applications of unit record equipment and computers in system design, including order writing, billing, sales analysis, accounts receivable, inventory control, payroll and labor accounting, accounts payable, general ledger, laboratory use of data processing equipment. Case studies. (Not open to students who have taken IE 316.) Prerequisite: Knowledge of computer programming.

Also listed under MG 716

IE 720 Optimum Seeking Methods* 2½:0:3
Algorithmic construction and applications of computer-implemented search procedures. One-dimensional searches, including Fibonacci and golden section search; quadratic and conjugate directions and variable metric (e.g., DFP) methods, Constraints, penalty functions, SIMPLEX. Sensitivity, convergence and program efficiency. Prerequisites: IE 601 and either IE 627 or IE 631.

IE 727 Case Studies in Management Science* 2½:0:3
Application of scientific and analytical methods to solving management decision-making problems, drawn from current practice and literature. Prerequisite: Instructor's permission.

Also listed under MG 727

IE 757 Technology Transfer to Developing Countries* 2½:0:3
Levels of technology: village, intermediate, advanced. Mechanisms of technology transfer to less-developed countries. National and international means to stimulate or block transfer. Ecological, social, economic factors in technology selection and utilization. Technology and political influence. Case studies of recently industrializing nations. (Not open to students who have taken IE 357.)

Also listed under MG 757 and SS 757

IE 758 Human Resource Development in Developing Countries* 2½:0:3
Spectrum of technology-related manpower needs in less-developed countries; education of engineers, technicians and skilled mechanics. Using foreign personnel, foreign schools, "brain-drain" problems. Economic consequences. Comparisons of educational systems of Western, Eastern and developing countries. Design of curricula to suit national needs. Role of technical assistance programs. Forecasting of human resource needs. (Not open to students who have taken IE 358.)

Also listed under MG 758 and SS 767
IE 765 Human Factors in Engineering Design* 2:1:3
Study of research techniques that yield information important in man-machine systems design. Man's learning, problem-solving, physiological and information processing capabilities, performance under various environmental conditions. (Not open to students who have taken IE 365.) Prerequisite: SS 189.

IE 775 Industrial Safety Engineering* 2:2:0:3
Analysis and design of industrial accident prevention, control and management systems. Effect of OSHA, Workmen's Compensation and environmental factors in implementing safety programs. Project work involves safety inspection and control and management of hazards. (Not open to students who have taken IE 575.)

IE 776 Manufacturing Resource Planning 2:2:0:3
Quantitative models for analysis of production and inventory management systems. Topics covered include bill of material structures, time-phased parts requirements, shop loading and capacity constraints, priority planning and control, and schedule regeneration. Development of computer-based MRP systems. (Not open to students who have taken IE 376.) Prerequisite: IE 619 or instructor's permission. Knowledge of computer programming.

IE 777 Manufacturing Improvement Curves* 2:2:0:3
Development of learning-curve theory, analysis of various improvement curve models and estimation of parameters. Applications of improvement curves are incorporated in evaluating work standards, wage incentives, training and labor turnover costs, inventory control, price policy and production schedules. (Not open to students who have taken IE 377.) Prerequisite: IE 606.

IE 778 Advanced Production Planning* 2:2:0:3
Quantitative analysis of aggregate planning models using optimal, heuristic and search decision rules. Expansion and contraction models for material and resource requirements. Algorithms for scheduling manpower for continuous operations. Selected topics in operational planning from recent research literature and assigned independent study. Prerequisite: IE 619.

IE 779 Advanced Work Systems Design* 2:2:0:3
Study of work design with emphasis on parameters affecting installation of overall system. Advanced work shaping, workforce balancing, ergonomic work loads, incentive for machine-controlled operations, computer-assisted planning of systems. Prerequisite: IE 606.

IE 846 Urban Systems Analysis 2:2:0:3
The overall urban system. Modeling for prediction and management of major components: population, economy, land use, transportation network, facility location, governmental service systems. Cost-benefit viewpoint in social welfare context. (Not open to students who have taken IE 346, except with instructor's permission.) Prerequisite: IE 627 or equivalent.

IE 851 Stochastic Processes* 2:2:0:3

IE 852 Applied Regression and Analysis of Variance 2:2:0:3
Analysis of observed data by means of regression and analysis of variance and covariance. Multiple regression in matrix notation. Systematic treatment of analysis of multiple classifications involving fixed and random effects and crossed and nested variables of classification. Regression analysis and its relation to analysis of variance. Use of BMD and SPSS program packages. Prerequisites: MA 153 and IE 606.

IE 853 Design of Experiments 2:2:0:3
Basic designs for scientific and industrial experiments. Single-factor and multiple-factor completely randomized designs, randomized blocks, incomplete blocks, orthogonal contrasts, general regression approach. Latin and higher squares, quantitative factors—orthogonal polynomials, complete and fractional factorial experiments including confounding methods. Use of BMD and SPSS program packages. Prerequisite: IE 606.

IE 870 Games and Decisions* 2:2:0:3

IE 911-912 Selected Topics in Operations Research and Industrial Engineering I, II* each 2:2:0:3
Areas not covered in other courses. Specific topics vary according to instructor, who may be a visiting professor. Topics and prerequisites announced during term prior to offering.

IE 913 Selected Topics in Operations Management* 2:2:0:3
Areas not covered in other courses. Specific topics vary according to instructor, who may be a visiting professor. Topics and prerequisites announced during term prior to offering.

IE 920 Research Seminar in Operations Research and Industrial Engineering* 2:2:0:3
Examination of selected advanced topics at research frontiers of department's graduate program areas. Presentations by graduate students, faculty, visiting scientists. Prerequisite: candidacy status for a graduate degree or permission of the course coordinator.

IE 930-931 Readings in Industrial Engineering I, II each 3 units
Individual reading of selected papers and current literature in specialized area of study, guided by faculty member. Prerequisite: approval of adviser, instructor and department head.

IE 935 Engineering Projects Related to Public Administration each 3 units
See Cooperative Program with New York University's Graduate School of Public Administration for details.

IE 997 Thesis for Degree of Master of Science 3 units
Original investigation in topic chosen by student. Conference and progress reports required during work and final written report required. Oral examination may be requested by department. Registration and degree credit beyond first six units require separate approval. Prerequisites: degree status and approval of supervising professor, adviser and department head.

IE 998 Project for Degree of Engineer 3 units
Post-master's investigation of significant problem, utilizing modern techniques of analysis and design. Project to be selected and developed in consultation with faculty member. Written report required, after which student is examined orally. Six units must be accumulated. Prerequisites: degree status and supervising professor's approval.
IE 999 Dissertation for Degree of Doctor of Philosophy each 3 units

Doctoral dissertation must give evidence of and embody results of extended research in specific field of industrial engineering, constituting original contribution. Candidate required to take oral examination on subject of thesis and on related topics. Minimum of 24 units required. Prerequisite: completion of qualifying examination and guidance committee's approval.

FACULTY

Walter Holly, Professor of Operations Research and Head of Industrial Engineering and Operations
Research
B.A., Cornell University; M.S., University of Illinois; Ph.D., Massachusetts Institute of Technology
Stochastic modeling, tele- and vehicular traffic, urban systems

John Chu, Professor of Operations Research and Management Science
B.S., University of Chekiang (China); M.S., Ph.D., Iowa State University
Managerial decisions, behavioral approach, national and international affairs

Norbert Hauser, Professor of Industrial Engineering and Management Science
Modeling of social systems, computer simulation, quality control

John H. K. Kao, Professor of Industrial Engineering and Operations Research
B.S., National Central University (China); M.S., Eng.Sc.D., Columbia University
Probability and statistics, quality control and reliability, scientific computing, electronic data processing

Joachim I. Weindling, Professor of Operations Research and System Engineering
B.M.E., City College of New York; M.S., Ph.D., Columbia University; Professional Engineer (N.Y., Pa.)
Mathematical programming, optimum design, economic evaluation

Herman Grau, Associate Professor of Industrial Engineering and Director of Manufacturing Engineering Program
B.M.E., Polytechnic Institute of New York; M.I.E., New York University
Methods, work measurement, project management, manufacturing engineering, industrial management

Seymour Kaplan, Associate Professor of Operations Research and Management Science
B.S., Newark College of Engineering; M.S., Ph.D., New York University
Economic modeling, linear programming

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management
B.Sc., Banaras Hindu University (India); M.S., Ph.D., University of Illinois
Production and operations planning, productivity analysis, project control

Vincent K. Omachonu, instructor of Industrial Engineering and Operations Management
B.S.E., M.S., University of Miami
Productivity management, human factors

ADJUNCT FACULTY

George R. Hazeltine, Adjunct Professor
B.S., M.S., New Jersey Institute of Technology; M.S.E., M.A., Ph.D., Princeton

Peter Meier, Adjunct Professor
B.S., Swiss Federal Institute of Technology (Zurich); M.S., Ph.D., University of Massachusetts

Lawrence M. Parks, Adjunct Professor
B.S., M.S., Ph.D., Polytechnic Institute of New York

Steven Kolman, Adjunct Associate Professor
B.S., M.B.A., New York University

Molra LeMay, Adjunct Associate Professor
B.S., Queens College; M.S., Ph.D., Pennsylvania State University

Robert A. Marose, Adjunct Associate Professor
B.S., Notre Dame; M.S., Stevens Institute of Technology; M.S., Adelphi University; Ph.D., Polytechnic Institute of New York

Andrew Siapos, Adjunct Associate Professor
Engineering Diploma, Technical University, Budapest; M.S.C.E., University of Pennsylvania

William Ying, Adjunct Associate Professor
B.S., Cornell University; M.S., Ph.D., Columbia University

Young W. Yoon, Adjunct Associate Professor
B.A., Yonsei University; M.B.A., New York University; Ph.D., Polytechnic Institute of New York

Aautos Chakrabarti, Adjunct Assistant Professor
M.S., Calcutta University; M.S., New York University

Sailbalesh Mukhopadyay, Adjunct Assistant Professor
B.S., Calcutta University; M.S., Ph.D., Polytechnic Institute of New York

Chaim Steinberger, Adjunct Assistant Professor
M.S., Polytechnic Institute of New York

Peter Wan, Adjunct Assistant Professor
B.S., Taiwan Chung Yuan; M.S., Kansas State University

David Einbinder, Lecturer
B.S., City College of New York

Michael P. London, Lecturer
B.S., M.S., Ph.D., New York University

Walter Vasilaky, Lecturer
B.A., Rutgers University; M.A., University of Maryland; Ph.D., Courant Institute of Mathematical Sciences

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INFORMATION MANAGEMENT

Information management deals with information needed by management for decision making. It includes, but is not limited to, electronic data processing (EDP), data base management (DBM) and management information systems (MIS). Computers are widely used to provide management with timely information needed to make decisions.

Currently, there is great demand for graduates in this field. Industries in the metropolitan New York area—such as banking, finance, retailing, utilities and hospitals, as well as manufacturing—have been unable to meet employment requirements in information management for the past several years. A typical position calls for technical competence and the ability to work closely with computer operations personnel, auditors, consultants and user department representatives, in addition to other project team members.

Polytechnic trains information management professionals who, after graduation, are usually assigned individual or team tasks, which they are expected to complete independently and with minimal supervision.

UNDERGRADUATE PROGRAM

Polytechnic offers a program of study, administered by the Division of Management, leading to the bachelor of science degree in information management. Students are offered both day and evening courses on a full- or part-time basis.

The program's objective is to provide students with the educational background and skills to qualify for the entry level positions as applications programmers or analysts in the business world. Unlike computer science, where mathematics, science and software development are emphasized, information management is business oriented. The student must be aware of the types of problems encountered by management which require timely information.

This in-depth program enables interested students to move into project leadership positions within one to five years of entering industry without additional course work. Finally, the program will provide a solid foundation for the academically inclined student who wishes to pursue graduate study.

Requirements for the Degree of Bachelor of Science in Information Management

The curriculum, requiring 128 credits for graduation, consists of four components: computing, management/system analysis, arts and sciences, and electives.

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing: CS 111, CS 203, CS 204, CS 205, CS 211, CS 217, IE 316, MG 736</td>
<td>24</td>
</tr>
<tr>
<td>Management/System Analysis: MG 304, IE 254, IE 300, IE 320, MG 300, MG 401, MG 630, MG 606, IE 314</td>
<td>27</td>
</tr>
<tr>
<td>Humanities/Social Science: HU 101, HU 110, HU 200, SS 189, SS 199, SS 251, SS 252</td>
<td>24</td>
</tr>
<tr>
<td>Mathematics: MA 101-102, MA 231</td>
<td>11</td>
</tr>
<tr>
<td>Physical Education: PE 101-104</td>
<td>0</td>
</tr>
<tr>
<td>Electives** Humanities/Social Science</td>
<td>6</td>
</tr>
<tr>
<td>Laboratory Science</td>
<td>6-8</td>
</tr>
<tr>
<td>Computing</td>
<td>9</td>
</tr>
<tr>
<td>Technical</td>
<td>6</td>
</tr>
<tr>
<td>Free</td>
<td>13-15</td>
</tr>
<tr>
<td>Total</td>
<td>128</td>
</tr>
</tbody>
</table>

ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101-104 (physical education); juniors and seniors may substitute three of the following two-credit courses: MS 301, 303, 401, or 403, for six credits of technical electives.

Graduate courses may be taken as electives by qualified juniors and seniors with at least a B average, who obtain their adviser's approval. If the total number of credits exceeds those required for the bachelor's degree, these graduate credits may be credited toward a graduate degree in accordance with current Polytechnic policy.

Four-Year Program. A typical program sequence is shown covering eight semesters. Students may rearrange courses and increase or decrease load per semester to suit their educational needs, provided prerequisites are not violated.

** See notes under typical course of study.
A five-year cooperative education program is available that permits students to integrate academic courses and career preparation in order to develop an understanding regarding their career choice and realistically evaluate their career decision. While earning the B.S. degree, students are also provided with a chance to earn up to 75 percent of college expenses. Students who wish a less intensive work experience as part of their education, may wish to enroll in a summer internship with their adviser’s permission.

Transfer students from other accredited institutions are accepted into the B.S. program after evaluation of their transcripts by a faculty adviser. Graduates of technology programs may be able to fulfill the bachelor’s degree requirements in two to three-and-one-half years, depending upon the scope and level of their previous education.

Typical Course of Study for the Bachelor of Science Degree in Information Management

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>CS 111</td>
<td>Comp. Progr. I</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>HU 101</td>
<td>College Composition</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>SS 251</td>
<td>Microecon.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SS 104</td>
<td>Main Themes in Cont. World History</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 101</td>
<td>Phys. Ed.</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sophomore Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>IE 254</td>
<td>Intro to Ind. Eng.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>CS 203</td>
<td>Comp. Progr. II</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>HU 110</td>
<td>Basic Rept. Writ.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 103</td>
<td>Phys. Ed.</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electives**</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>IE 300</td>
<td>Proj. Fl. &amp; Contr.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MG 300</td>
<td>Mgt. Process</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>SS 189</td>
<td>Introd. to Psych.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>CS 205</td>
<td>Assmb. &amp; Mech. Lang. Prog. Electives**</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>16*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Senior Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>IE 314</td>
<td>Mod. of Soc. Syst.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MG 330</td>
<td>Operations Mgt.</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MG 605</td>
<td>Managerial Finance Electives**</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>15*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Actual number of credits in a particular term may differ, depending upon electives chosen.
*Electives: 42 credits, distributed as follows.
Laboratory Science: one of the following sequences 6-8 credits
CM 091-092 6 cr
CM 101-102, 111, 112 12
LS 103-105, 115 8
PH 091-092 6 cr
Total credits required for graduation 128
FACULTY

The program is administered by the Division of Management. The faculties of industrial engineering, operations research, management and computer science, which play major roles in information management, are listed below.

Richard Sonnenfeldt, Professor and Dean of Management

John T. Chu, Professor of Operations Research and Management Science

Norbert Hauser, Professor of Industrial Engineering and Management Science

Walter Kelly, Professor of Operations Research, and Head of Industrial Engineering and Operations Research

John H. K. Kao, Professor of Industrial Engineering and Operations Research

Melvin Klerer, Professor of Computer Science

Arthur E. Laemmel, Professor of Electrical Engineering and Computer Science

Jack Machanik, Industry Professor and Director of Center for Digital Systems

Stanley Preiser, Professor of Mathematics and Computer Science

Martin L. Shooman, Professor of Electrical Engineering and Computer Science and Director of Division of Computer Science

Edward J. Smith, Professor of Electrical Engineering

Joe Snyder, Industry Professor

Joachim I. Weindling, Professor of Operations Research and Systems Engineering

Anthony J. Weiner, Professor of Management

Herman Grau, Associate Professor of Industrial Engineering

Ronald Juels, Associate Professor of Computer Science

Seymour Kaplan, Associate Professor of Operations Research and Management Science

Harold G. Kaufman, Associate Professor of Management

Aaron Kershenbaum, Associate Professor of Computer Science

Aaron D. Klappholz, Assistant Professor of Computer Science

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management, Co-Director of Operations Management Program

Henry Ruaton, Associate Professor of Electrical Engineering and Computer Science

A. George Schilling, Associate Professor of Management

Melvin L. Meer, Assistant Professor of Management

David A. Schrier, Assistant Professor of Management, Co-Director of Operations Management Program

Wang-Chuan Tsai, Assistant Professor of Computer Science

Joseph S. Fulda, Instructor of Computer Science

Linda Anne Grieco, Instructor of Computer Science

Vincent K. Omachoni, Instructor of Industrial Engineering and Operations Management

Michael J. Post, Instructor of Computer Science

Evelyn Gail Roman, Instructor of Computer Science

Thomas Conoscenti, Academic Associate, Management

Madhuri Kadiyala, Academic Associate, Management

Subash C. Midha, Academic Associate, Management
INTER-INSTITUTIONAL and COOPERATIVE PROGRAMS

The Polytechnic Institute of New York has made cooperative arrangements with other institutions in order to expand the offerings available to students. Some of these programs are described in this section. All students who wish to participate in a cooperative program should discuss their needs and goals with advisers at both institutions.

NEW YORK UNIVERSITY/POLYTECHNIC COOPERATIVE PROGRAM

Program Aims

Engineers and scientists increasingly find themselves drawn into problem areas requiring interactions with public policy planners. Similarly, public administrators find themselves increasingly confronted with problems of substantial technical impact. The joint program between New York University and Polytechnic (developed under National Science Foundation sponsorship) leads simultaneously to the degrees of master of science and master of public administration, and has been designed to be the ideal solution for both persons.

Cooperating Science and Engineering Programs at the Polytechnic

The M.P.A. degree will be awarded by New York University on successful completion of the program. The M.S. degree will be awarded simultaneously by the Polytechnic Institute of New York in one of the following programs:

- Aeronautics and Astronautics
- Applied Mechanics
- Bioengineering
- Chemical Engineering
- Chemistry
- Civil Engineering
- Electrical Engineering
- Industrial Engineering
- Mathematics
- Mechanical Engineering
- Metallurgical Engineering
- Nuclear Engineering
- Operations Research
- Physics
- System Engineering
- Transportation Planning

Program Eligibility and Duration

The program is open to qualified students with an acceptable undergraduate background in mathematics, science or engineering, some departments will accept students from quantitatively-oriented social science programs. Students must be admitted through one of the cooperating departments at the Polytechnic Institute of New York for one of the M.S. programs, as well as through the Graduate School of Public Administration of New York University. The joint program involves two years of full-time study or equivalent part-time study. It should be noted that the joint program provides for a significant time saving compared with sequential study for the two master's degrees.

It is assumed that the student has an undergraduate science or engineering background that is essentially equivalent to a Polytechnic degree. Students with deficiencies in their undergraduate preparation may be required to take additional credits for the completion of the degree. Students are expected to be familiar with elementary digital computational procedures and with a programming language such as FORTRAN or PL/1. Students without this background should take IE 601 (Introduction to Digital Computing) or CS 530 (Introduction to Computer Science).

Joint Program Requirements

The following requirements must be met by all students in the program. The minimum of 60 credits is divided into six groups:

1. Departmental Engineering or Science Courses (24 credits). The specific required courses and suggested electives for each of the cooperating engineering and science programs conform to those shown in their respective sections of this catalog. A brochure summarizing them is available.

2. Courses in Mathematical Methods and Statistics (6 credits). Two courses in mathematical methods, of which one must be in statistical methods, unless an undergraduate or graduate course in that subject has been previously taken.

3. Required Courses in Public Administration (12 credits). All students take:
American Public Administration and its Political Environment
Organization Theory in a Public Context
Microeconomics for Public Management, Planning and Policy Analysis

Elective Courses in Public Administration
(12 credits) Three courses, usually in accordance with the suggestions shown by the Polytechnic program.

Project
(6 credits) In the following course description, the XX is replaced by the initials of the Polytechnic department:

XX 935 Engineering/Science Project
Related to Public Administration each 3 units
Students will work in groups of two to four on projects relevant to public policy and/or administration, selected in consultation with the faculty advisers from Polytechnic and New York University Graduate School of Public Administration. Each project will be supervised by the program coordinator of the respective Polytechnic school. Two semesters are required of all students during the second half of the joint M.S./M.P.A. program. A third term may be approved by the advisor. Prerequisite: completion of at least 27 credits in the joint program.

Seminar
(no credit) Joint seminars including guest speakers covering technical and scientific problems related to public policy. Participation will be required of all students in the program.

Project Topics – Actual topics will be determined by the students and their advisers

Admission – Applications for admission to the combined program are available from the program coordinator. Applicants should complete the application form for Polytechnic clearly indicating the desired Polytechnic program and the liaison officer of that school. Students will be assigned a Polytechnic advisor with whom the overall program should be planned. In addition, students will be assigned an advisor from NYU/GPA by the liaison officer of that school.

Financial Aid – Limited financial aid may be available to full-time students entering the program. Requests for financial aid in terms of assistantships should be indicated on the application form.

Registration – Students will formally register for their first year at Polytechnic and their second year at NYU/GPA. Students may take courses at both institutions during both years of the program. A minimum of 27 credits must be completed at Polytechnic and a minimum of 24 credits at NYU/GPA within the total minimum of 60 credits for both master’s degrees. At the time of the first registration, a student will be assigned a Polytechnic advisor with whom the overall program should be planned. In addition, students will be assigned an adviser from NYU/GPA by the liaison officer of that school.

Further Information – Additional information may be found in the NYU/GPA catalog. A brochure and application forms are available from the program director.

Professor Joachim I. Weindling
POLY/NYU Program Director
Polytechnic Institute of New York
333 Jay Street
Brooklyn, NY 11201

AIR FORCE RESERVE OFFICER TRAINING CORPS

Program
As a AFROTC cadet, the student is eligible to compete for an AFROTC scholarship — available to qualified applicants in both the four-and two-year programs — which pays full tuition, books and incidental fees. All cadets receive a stipend of $100 a month, tax free, during their junior and senior years. Upon graduation, the student will be commissioned a second lieutenant in the United States Air Force Reserve and assigned to a position commensurate with the degree specialty.

In order that a student may participate in the Air Force ROTC program, Manhattan College courses are offered on the Polytechnic campus (Brooklyn only). Courses are listed in the Course Bulletin each semester; every semester one general military course (GMC) and one professional officer course (POC) are offered.

Students may register for the AFROTC program at the same time and in the same manner as for other college courses at Polytechnic Institute of New York. Courses appear on the student’s Polytechnic transcript. Approval of these courses to satisfy Polytechnic degree requirements is at the discretion of the individual academic departments.

Basic Course Offerings

General Military Course (GMC)
This is a two-year course which is normally taken during the freshman and sophomore years. Two main themes are covered—the development of air power and the contemporary Air Force in the context of U.S. military organization.

AS 101-102 The Air Force Today I, II 1:1:1 each
The Air Force in the contemporary world through a study of the total force structure, strategic offensive and defensive forces, general purpose forces and aerospace support forces.

AS 201-202 The Development of Air Power I, II 1:1:1 each
The study of air power history which addresses politics, human failures and achievements as they relate to the evolution of air power as a primary element of national security, both in military and non-military operations.

Professional Officer Course (POC)
This is a two-year course of instruction normally taken during the junior and senior years. The curriculum covers Air Force management and leadership, and American defense policy.
Those wishing to pursue studies under the combined plan of their choice and should enroll in the plan at that school. They should make inquiry at the cooperating liberal arts college in which U.S. defense policy is formulated and implemented.

COOPERATIVE (2-2) ENGINEERING PLAN

A similar cooperative program, leading to a Polytechnic bachelor's degree in engineering, but without provision for a bachelor's degree in liberal arts, has been developed jointly with various liberal arts and community colleges. Under this plan, the student enrolls at a cooperating school for a two-year pre-engineering program. Upon satisfactory completion of the program, and with the official recommendation of the school, the student would be admitted to Polytechnic to complete requirements for the bachelor's degree in one of the fields of engineering, a process expected to require four or five semesters of additional study. The Polytechnic Institute of New York has formal agreements for cooperation in this plan with the following institutions:

- Brooklyn College (City University of New York)
- Brooklyn, N.Y.
- Lehman College (City University of New York), Bronx, N.Y.
- Westchester Community College, Valhalla, N.Y.

TRANSFER FROM BROOKLYN COLLEGE

The Polytechnic Institute of New York and Brooklyn College (City University of New York) have developed, under the Cooperative (2-2) Engineering Plan, a coordinated engineering degree program. Students admitted to the Coordinated Brooklyn College/Polytechnic Program attend Brooklyn College for two years of pre-engineering studies. On completion of the Brooklyn College component of the coordinated program, the student transfers to the Polytechnic Institute of New York for an additional two to three years of study to fulfill the requirements for the degree of Bachelor of Science in one of the following fields: Aerospace, Chemical, Civil, Electrical, Industrial, Mechanical, or Metallurgical Engineering.

Students who complete the Brooklyn College pre-engineering component with an overall science and mathematics course grade index of 2.5 or higher are guaranteed transfer into a Polytechnic engineering program, with all Brooklyn College course credits transferrable toward the Polytechnic degree.

Polytechnic offers transfer students in the Coordinated Brooklyn College/Polytechnic Program financial aid, based on family need and scholarship, which is comparable to the assistance offered to continuing Polytechnic students in their junior year.
Further information and copies of the full four-year suggested programs in engineering may be obtained from:

Professor L. Mendelsohn, Dept. of Physics
Brooklyn College (CUNY)
Bedford Avenue & Avenue H
Brooklyn, New York 11210
Phone: (212) 780-5418

CROSS REGISTRATION WITH LONG ISLAND COLLEGES

Through a consortium of Long Island Colleges, LIRACHE (Long Island Regional Advisory Council on Higher Educations), cross registration opportunities are available to both full- and part-time matriculated undergraduates during the two regular semesters of the academic year. Cross registration permits access to courses not available at the student’s home institution.

The following conditions prevail; exceptions may be made only under unusual or extenuating circumstances:

• Permission is granted only when the home institution does not offer the course at any time.

• Students must receive approval from both the home and the host institution for each cross-registered course prior to admission.

• No cross registration fees will be charged. Students are obligated to pay to the home institution regular tuition which would be charged if the course had been taken at the student’s own school; however, students are responsible for any special fees charged by the host institution. Such fees are paid directly by the students to the institution at which they cross register.

• Grades (in each course) are sent directly to the Registrar of the student’s home institution, and are processed thereafter in the manner of that school.

• Students participating in this academic enrichment program are subject to the academic regulations, including grading system, calendar deadlines, and academic honor system of the host institution.

Participating institutions are:

NASSAU County:
Adelphi University,
C.W. Post of L.I.U.,
Molloy College,
Nassau Community College,
N.Y. Institute of Technology,
SUNY College at Old Westbury

SUFFOLK County:
Polytechnic (L.I. Center),
St. Joseph’s/Brentwood,
SUNY at Farmingdale,
Dowling College,
SUNY at Stony Brook,
Southampton College,
Friends World College.

LIRACHE reviews this program periodically, and it is therefore subject to change and/or cancellation. For further information consult the registrar’s representative at the Farmingdale Campus.
Among the programs offered by the Division of Management are an undergraduate bachelor of science degree in information management* and two graduate degrees: master of science in management** and master of science in organizational behavior. The graduate degrees are primarily evening programs offered to both full-time and part-time students.

Both graduate programs are open to any student who has earned a bachelor's degree from an accredited school. Students who show potential for advanced study but have undergraduate averages below B may be admitted to nondegree status; satisfactory performance at Polytechnic will permit later application for degree status.

In addition to the programs listed below, students may be interested in Institute offerings in economic systems analysis, operations management and operations research. These programs are listed elsewhere in this catalog.

**MASTER OF SCIENCE PROGRAM IN MANAGEMENT**

The Program—This program is aimed at developing a competence in planning and decision-making and in the selection, allocation and direction of human, financial, physical, technological and organizational resources.

These management skills can be applied in a broad range of professional settings: in the private as well as in the public sector; in labor-intensive as well as in capital-intensive industries; in production-oriented as well as in service-oriented activities; and in low-technology as well as in high-technology environments. The program emphasizes a pragmatic approach to management and is intended to train professional managers who can function effectively in complex managerial systems.

Admission—In addition to holding an accredited bachelor's degree, each student must take the Graduate Management Admission Test (GMAT) or an acceptable equivalent test. Students who have not taken the test may be admitted to a nondegree status and will be required to take it at its next sitting, preferably during the current semester.

Degree Requirements—The maximum of 48 units at an overall B average performance may be reduced by waivers of not more than four core courses, and further reduced by not more than nine evaluated transfer graduate course credits.

The Curriculum

1. Core Courses. A business administration base, designated as the management core, consists of eight core courses upon which a heterogeneous student body can build a variety of specializations within the degree programs. Core courses provide intensive introductions to the several disciplines that are basic to professional management. Students who have taken courses in any of these areas elsewhere, or who have had substantial equivalent experience, may be excused from taking them; on proof of competence, the adviser may waive the corresponding core courses.

The core courses are:

- MG 600 Management Process
- MG 601 Organizational Behavior
- MG 602 Computers in Management
- MG 603 Economic Environment of Management
- MG 604 Managerial Accounting
- MG 605 Statistical Analysis
- MG 606 Managerial Finance
- MG 607 Marketing Management

2. Areas of Concentration: The student must choose an area of concentration. This may be one of those listed below or, with the adviser's approval, may consist of a set of courses designed to meet the student's special needs. A minimum of five courses must be selected in the student's area of concentration.

Courses in each of the following available options are shown below:

- Computer Applications
- Construction Management
- Economics and Finance
- Energy Management
- Human Resources Management
- Management and Business Administration
- Management Science
- Public Policy
- Technology Management
- Transportation Management

3. Free Electives. Two graduate courses may be chosen from those offered by any program of Polytechnic. They may include additional courses from

*See Section "Information Management"

** Master of science in management (MSM) is recognized, along with the master of business administration (MBA), by the Graduate Management Admission Council as a graduate professional management degree.
the student's or other concentrations but may not include core courses.

4. Business Policy and Strategy with Project (MG 970). This required integrating course is recommended to be taken during the student's final semester. It includes a project, normally in the area of the student's specialization.

Concentration Course Requirements

Each concentration sequence consists of five courses. If students wish to take more than the minimum number of required courses, they may count the additional courses as electives. Substitution may be made with the advisor's approval in any concentration area.

Computer Applications

Select five:
CS 603 Information Structures and Algorithms
MG 716 Commercial Data Processing System and Design
MG 736 Analysis and Design of Management Information Systems
IE 614 Modeling of Social Systems I
IE 680 System Simulation I
IE 776 Materials Requirement Planning
MG 636 Cobol Programming

Construction Management

Select five:
MG 631 Theories of Complex Organizations
MG 810 Project Planning and Control
MG 820 Project Management
MG 825 Construction Administration
MG 826 Construction Estimates and Costs
MG 827 Specifications and Contracts

Economics and Finance

Required:
MG 782 Managerial Economics
MG 783 National Economic Models and Forecasting
MG 766 Financial Institutions

Electives—(select two):
MG 615 Labor Economics
MG 640 Resource Economics
MG 671 Business and Economic Forecasting
MG 672 Technological Forecasting
MG 860 Financial Planning, Internal Reporting and Operational Control
MG 912 Seminar in Investment Analysis
MG 963 Seminar in Financial Planning and Control

Energy Management
(Refer to Energy Program)

Required:
ES 927 Energy Policy Issues
ES 928 Energy Resources, Distribution and Conversion Technology

Electives: Select three:
MG 631 Theories of Complex Organizations
MG 640 Resource Economics
MG 664 Legal Environment of Business
MG 965 Research, Development and Management of Innovation
MG 865 Technology Management and Policy

Human Resources Management

Required:
MG 612 Human Resources Management
MG 624 Organization Development
MG 633 Research Methods

Electives—(select two):
MG 611 Career Management
MG 613 Industrial Relations
MG 622 Personnel Psychology
MG 623 Training in Organizations
MG 625 Seminar in Career Management
MG 631 Theories of Complex Organizations

Management and Business Administration

Select five:
MG 612 Human Resources Management
MG 624 Organization Development
MG 630 Operations Management
MG 633 Research Methods
MG 664 Legal Environment of Business
MG 705 Managerial Planning Process
MG 762 Managerial Economics

Management Science

Students electing this option should substitute IE 601 for MG 602 and MA 551 for MG 605 in the required core courses.

Note that IE 624 has several prerequisites.

Select five:
MG 810 Project Planning and Control
IE 614 Modeling of Social Systems I
IE 624 Computer-Augmented Case Studies in Management Science
IE 627 Operations Research: Deterministic Models
IE 628 Operations Research: Stochastic Models
IE 680 System Simulation I

Public Policy

Select five:
MG 640 Resource Economics
MG 740 Process of Policy Formation
MG 746 Public Sector Management
MG 800 Policy Analysis and Planning
MG 865 Research Development and Management of Innovation
ES 927 Energy Policy Issues
IE 614 Modeling of Social Systems
Technology Management

Select five:
MG 624 Organization Development
MG 630 Operations Management
MG 645 Productivity Management
MG 672 Technological Forecasting
MG 758 Technology Transfer for Developing Countries
MG 820 Project Management
MG 865 Research Development and Management of Innovation
MG 866 Technology Management and Policy
IE 614 Modeling of Social Systems

Transportation Management

Select five:
MG 852 Legal and Regulatory Aspects of Transportation
MG 853 Public Finance and Economics in Transportation
MG 855 Analysis of Transportation Markets
MG 857 Transportation Management
MG 858 Transportation Policy and Decision-Making
TR 750 Transportation Economics

MASTER OF SCIENCE PROGRAM IN ORGANIZATIONAL BEHAVIOR

Program—A graduate evening program is offered to students who wish to specialize in the area of organizational behavior, a field concerned with solving human problems in modern organizations. The program, which includes theoretical and practical courses relevant to organizational behavior, integrates the latest contributions from management, psychology and sociology.

Admission—Applicants must hold an accredited bachelor's degree in any field. Those without undergraduate courses in psychology will be required to remove this deficiency. Applicants must take the Graduate Record Examination (GRE) or Graduate Management Admissions Test (GMAT) and have scores submitted directly to Polytechnic in advance of the application.

The Curriculum

1. Required Core Courses. An organizational behavior base consists of five core courses upon which the student can build a variety of specializations within the degree program. Core courses provide intensive introduction to several areas that are basic to organizational behavior. Students who have previously completed courses in any of these areas or have had substantial equivalent experience may be excused from taking them by presenting proof of competence and receiving a waiver from the adviser.

The core courses are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>MG 600</td>
<td>3</td>
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<tr>
<td>MG 601</td>
<td>3</td>
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<tr>
<td>MG 605</td>
<td>3</td>
</tr>
<tr>
<td>MG 631</td>
<td>3</td>
</tr>
<tr>
<td>MG 633</td>
<td>3</td>
</tr>
</tbody>
</table>

Total units required: 15

2. Areas of Concentration. The student must choose two areas of concentration, each consisting of two courses. These may be two of those listed below or, with the adviser's approval, may consist of a series of four courses designed to meet the student's special needs.

Courses in each of the following available areas of concentration are shown below:

Training and Development

MG 622 Training in Organizations
MG 624 Organization Development

Industrial Relations

MG 613 Industrial Relations
MG 614 Collective Bargaining

Careers

MG 611 Career Management
MG 625 Seminar in Career Management

Personnel/Human Resources

MG 612 Human Resources Management
MG 622 Personnel Psychology

3. Free Electives. Two appropriate graduate courses may be chosen from those offered by any program at Polytechnic. These could include courses from any of the concentrations not required in the student's program, other courses in the management division, or courses in computers, psychology and social sciences.

4. Research Project. All students are required to complete a research project, submitted as part of the requirements for MG 634 Applied Research Methods.

CERTIFICATE PROGRAMS

The Division of Management offers several certificate programs designed for the professional with work experience. A certificate program requires five courses, which are selected in line with the needs of the individual. Applicants for a certificate program must hold a bachelor's degree. On completion of a sequence with a B average or better, the individual is issued a certificate. Students who choose to work toward a master's degree are able to apply all courses taken toward a certificate on admission to the degree program. Additional information may be obtained from the division.

Management Certificate—This program is designed to foster professional and personal growth through an intensive examination and study of the latest advances...
in management process and the newest quantitative techniques, ranging from management information systems to decision models. Management certificates are offered in the following fields:

Computer Applications
Construction Management
Economics
Energy Management
Finance
Human Resources
Management & Business Administration
Operations Management
Public Policy
Technology Management

Organizational Behavior Certificate—This program involves an intensive examination and study of the latest knowledge and techniques for dealing with human problems in the organization. The individualized program makes it highly appropriate for specialists as well as generalists who desire to improve and update their knowledge and skills in areas ranging from individual motivation to organizational development.

UNDERGRADUATE COURSES

MG 300 Management Process 3:0:3
Introductory management course for undergraduates. Primary focus is the management process: planning, organizing, staffing, controlling, directing, and decision-making. Attention is given to the roles of the various disciplines within management as well as to the traditional business functions of marketing, accounting, finance, production, engineering, and research and development.

MG 301 Organizational Behavior 3:0:3
Study of behavior in industrial settings. Emphasis on informal and formal group dynamics, interpersonal relationships, supervision, leadership, communication theory, attitude measurement, creativity. Analysis of administration problems by case studies and simulated situations. Prerequisite: SS 189
Also listed under SS 199

MG 304 Accounting Fundamentals 3:0:3

MG 401 Senior Project 3 credits
Independent work integrating the student's knowledge under faculty guidance. Student will design a system required to manage information regarding a specific management function. Prerequisite: senior standing in information management.

GRADUATE COURSES

MG 600 Management Process 2:5:0:3
Establishment of a conceptual perspective of major schools of management thought; including scientific management, classical administrative theory, human relations, behavioral system theories.

MG 601 Organizational Behavior 2:5:0:3
Integration of behavioral science theory, concepts, research and techniques for understanding of human behavior in organizations. Motivation and job satisfaction, personality and conflict, group dynamics, interpersonal relationships, supervision and leadership, communications, organization structure and process. Impact of technology, career development.

MG 602 Computers in Management 2:5:0:3
Computer literacy for management problem-solving. Information systems, computer technology, software and vocabulary. Advantages and disadvantages of alternatives ranging from large mainframes to time-sharing, networking, batch processing, personal computers and programmable calculators. Survey of software, compilers, interpreters, assemblers and languages important to managers. Examples and cases of decision support systems and their operation in office automation, financial analyses and other business applications.

MG 603 Economic Environment of Management 2:5:0:3
Central problems of economic society, supply and demand analysis, structure of industrial markets, factors of production, prices and incentives, national income accounting, income determination, business cycles, monetary and banking systems, governmental influences on the economy, international trade and finance.

MG 604 Managerial Accounting 2:5:0:3

MG 605 Statistical Analysis 2:5:0:3
Fundamental statistical models and their use in decision-making. Emphasis on alternative techniques, their assumptions and limitations. Topics include: descriptive statistics, probability—concepts of probability, probability distributions both discrete and continuous; sampling, methods, estimation, hypothesis testing, regression and correlation analysis, time series, chi-square testing.

MG 606 Managerial Finance 2:5:0:3
Analysis of principles and practices of the finance function and its application in organizations. Survey of use of financial instruments, sources and uses of short- and long-term loans available to business, capital budgeting under certainty and uncertainty, cost of capital and dividends policy, working capital management. Co/Prerequisite: MG 604 or equivalent.

MG 607 Marketing Management 2:5:0:3
Foundation course in marketing. The marketing processes and institutions, consumer motivation and behavior, pricing determination and rationale, product planning and development, promotion management, channels and means of distribution, influences of government, managerial aspects stressed. Co/Prerequisite: MG 603.

MG 611 Career Management 2:5:0:3
An examination of careers from the perspectives of both management and the individual. Specific issues addressed include career stage models, organizational entry, career pathing, mid-career crisis, career change, continuing education and re-training, professional obsolescence, career re-entry, tokenism, job loss and underemployment. Existing career planning/development programs used by organizations will be evaluated. Prerequisite: MG 601 or permission of instructor.

MG 612 Human Resources Management 2:5:0:3
The personnel function is investigated from the perspective of both the individual manager and the total organization. Topics
include manpower characteristics, recruitment and development, motivation, performance evaluation and rewards, effects of government policy on legislation and the changing labor force. Prerequisite: MG 601 or permission of instructor.

MG 613 Industrial Relations 2½:0:3
Politics and philosophies of management, organized labor and government with regard to solution of labor problems. Evaluation of industrial relations problems, particularly those of collective bargaining, emphasizing interrelationships with social, economic and legal trends. Co/Prerequisite: MG 600 or permission of instructor.

MG 614 Collective Bargaining 2½:0:3
Analysis of nature of the collective bargaining process, its major issues and points of contention. Major trends examined with consideration given to broad economic and social implications. Prerequisite: MG 613 or permission of instructor.

MG 615 Labor Economics 2½:0:3
Analysis of the character and operation of labor markets through economic theory and empirical studies. Supply and demand, wages and employment "scientific management," job opportunities, governmental micropolicy, collective bargaining and internal markets. Discrimination, unemployment and inflation, poverty and income distribution. Prerequisite: MG 603 or equivalent.

MG 622 Personnel Psychology 2½:0:3
Examination of theory, research and practice concerning individual differences relating to organizational behavior with emphasis on the personnel selection process, measurement of predictors, criteria for validation and decision-making strategies. Prerequisites: MG 601 and MG 605 or permission of instructor.

MG 623 Training in Organizations 2½:0:3
The role of training in organizations focusing on department and line managers. Subjects addressed include need analysis, preparation of the employee for the job, management development, training program design, evaluation and employee obsolescence. Prerequisite: MG 601 or permission of instructor.

MG 624 Organization Development 2½:0:3
Applied theory and research related to process of managing change in organizations. Practical application of group, intergroup and individual change. Planned structural revisions in formal organizations. Dynamics of organizational change process. Experiential techniques and seminar approach emphasized. Prerequisite: MG 621.

MG 625 Seminar in Career Management 2½:0:3
An in-depth examination of the latest concepts, research and practices pertaining to professional and managerial careers in organizations. The emphasis is on current issues and problems in career management. Experts and resource materials will be utilized in the examination of research findings as well as in studying career development and planning practices in organizations that have been established in the field. Prerequisite: MG 611 or permission of instructor.

MG 630 Operations Management 2½:0:3
Analytical techniques for designing and operating production and service systems. Facility layout and location, assembly line balancing, job sequencing, inventory control, project planning and introductory linear programming.

MG 631 Organization Theory 2½:0:3
Analysis of theories of large-scale organizations focusing on characteristics of bureaucracy, suboptimization, human dynamics and informal systems, influence and control systems, planned change. Examination of both formal and informal organizations through wide variety of research studies. Prerequisite: MG 601 or permission of instructor.

MG 632 Business and its Environment 2½:0:3
Discussion of various environments of business (economic, political, legal, social), together with conflicting values in these environments. Prerequisite: MG 600.

MG 633 Research Methods 2½:0:3
An introduction to theory and techniques of research methods. Primary objective is to provide an understanding and appreciation of why and how organizational research is carried out. Survey of research methods. Research projects designed and analyzed. Prerequisite: MG 605 or permission of instructor.

MG 634 Applied Research Methods in Organizational Behavior 2½:0:3
Integration and application of advanced research techniques utilized in study of organizations. Students develop and carry out individual applied research projects. Prerequisite: MG 633 or permission of instructor.

MG 638 COBOL Programming 2½:0:3
Data processing and file processing using ANSI-COBOL. Structured programming used throughout. More than standard COBOL features such as report-writer module, multi-level table-handling are covered. Creting, use and updating of files on tapes and disks. Batch and time sharing processing. Prerequisite: MG 602 or a knowledge of computer programming. Also listed under CS 532

MG 640J Resource Economics 2½:0:3
Theories of exhaustible natural resources with special emphasis on fossil fuels. Theories of extraction logistics and resource exhaustion, extraction pricing and allocation of exhaustible resources under economic conditions of competition, monopoly and oligopoly. Present-day behavior of the world oil market and the domestic markets for natural gas and coal will be discussed, as well as energy problems. Prerequisites: SS 251 and MA 103, or IE 605, or permission of instructor.

MG 645 Productivity Management 2½:0:3
Modern approaches to productivity measurement, evaluation, planning and improvement in both manufacturing and service industries. Participants will develop productivity models for various types of organization. Prerequisite: Graduate standing or permission of instructor. Also listed under IE 645

MG 664 Management and the Legal System 2½:0:3
Impact of the legal system on corporate strategy, managerial decisions and planning processes. Issues covered will include: the protection of intellectual and technological property, consumer, contract, commercial, and secured financing law, employer liability to, and for, employees; constitutional and state regulatory aspects of conducting business on a multi-state (or multinational) basis, and the impact of legal and administrative structures and processes on substantive law.

MG 671 Business and Economic Forecasting 2½:0:3
Forecasting for managerial decision control. Statistical vs. judgmental methods. Smoothing and analyses of trends, seasonal factors, cycles and random variations. Econometric forecasting. Economic indicators and sources of information. Applications to the national economy, industry sales, corporate profits, financial institutions, government expenditures, etc. Prerequisite: IE 608 or equivalent. Also listed under IE 671
MG 672 Technological Forecasting 2 ½: 0: 3
Introduction to problems of technological forecasting. Morphological analysis, extrapolation of trends, heuristic and intuitive forecasts. Consideration of rational directing of technological change. Students prepare forecast on topic of own choice. Also listed under SS 672

MG 705 Managerial Planning Processes 2 ½: 0: 3
An introduction to strategic management and to formal planning as a method for translating the firm's goals into procedures or actions. Tactical planning at the operating level is stressed. One purpose of the course is to develop an appreciation of foresight and the classical methods for gathering information essential to decision-making in large-scale organizations. Prerequisites: MG 600 and MG 601.

MG 716 Commercial Data-Processing System Design 2 ½: 0: 3
Applications of unit record equipment and computers in system design, including order writing, billing, sales analysis, accounts receivable, inventory control, payroll and labor accounting, accounts payable, general ledger. Laboratory use of data-processing equipment. Case studies. Prerequisite: Knowledge of computer programming. Also listed under IE 716

MG 727 Case Studies in Management Science 2 ½: 0: 3
Application of scientific and analytic methods to solving management decision-making problems, drawn from current practice and literature. Prerequisite: Permission of the instructor. Also listed under IE 727

MG 736 Analysis and Design of Management-Information Systems 2 ½: 0: 3
The role of the information system in the management decision-making process. Detailed development of management-information systems through planning, design and implementation, introduction to information theory, the value of information. The information system and changes in the organization, examples and applications. Prerequisite: MG 602.

MG 740 Process of Policy Formation 2 ½: 0: 3
Situations faced by practitioners and alternative techniques employed to define issues, formulate policy goals and objectives, bargain over priorities, define implementation procedures and garner support.

MG 744 Social Forecasting 2 ½: 0: 3
How institutional, economic, social and cultural changes affect both private and public sector organizations in divergent—and sometimes dramatic—ways. Evaluation of methods employed to formulate forecasts and of how implicit beliefs and values of forecasters can subtly bias forecasts. Assessment of alternative forecasts. Prerequisite: MG 600.

MG 746 Public Sector Management 2 ½: 0: 3
Management in the public sector is distinguished by the political setting in which it occurs. It goes beyond technical canons of efficiency and economy to involve issues of social equity and political viability. This course is designed to show how these considerations alter the management decision-making process.

MG 757 Technology Transfer to Developing Countries 2 ½: 0: 3
Levels of technology: village, intermediate, advanced. Mechanisms of technology transfer to less-developed countries. National and international means to stimulate or block transfer. Ecological, social and economic factors in technology selection and utilization. Technology and political influence. Case studies of recently industrializing nations. (Not open to students who have taken IE 357.) Also listed under IE 757 and SS 675

MG 758 Human Resource Development in Developing Countries 2 ½: 0: 3
Spectrum of technology-related manpower needs in less developed countries. Education of engineers, technicians and skilled mechanics. Using foreign personnel, foreign schools, "brain-drain" problems. Economic consequences. Comparisons of educational systems of Western, Eastern and developing countries. Design of curricula to suit national needs. Role of technical assistance programs. Forecasting of human resource needs. (Not open to students who have taken IE 357.) Also listed under IE 758 and SS 676

MG 760 International Development: Management and Technology 2 ½: 0: 3
The course provides a framework for development issues of particular significance to students in engineering and management. Economics of science and technology, appraisal and management of development projects and programs, appropriate technology and mechanisms of technology transfer. Political criteria and the impact of technological decision on social and economic change in developing countries.

MG 762 Managerial Economics 2 ½: 0: 3
The development of micro-economic analysis and its application to business decision-making. Quantitative techniques, profit measurement, competition, oligopoly and monopoly, multiple product analysis, demand analysis and demand forecasting, cost analysis, pricing analysis, capital budgeting. Prerequisite: MG 603.

MG 763 National Economic Models and Forecasting 2 ½: 0: 3
Measures of aggregate economic activity. National income accounting, simple and complex national and regional macroeconomic models, the firm's position relative to the economic environment, introductory econometrics, econometric models of the national economy and their estimation, and the use of the analysis in the profit planning and strategic management of the firm and in the formulation of public policy. Prerequisites: MG 603 and MG 605.

MG 766 Financial Institutions 2 ½: 0: 3
Financial institutions and their relative importance in the economy. Capital and money markets, commercial banking system, federal banking system, investment banks, insurance companies, savings and loan associations, mutual funds, brokerage companies, international banking.

MG 800 Policy Analysis and Planning 2 ½: 0: 3

MG 810 Project Planning and Control 2 ½: 0: 3
Network planning techniques for project management and resource allocation. Emphasis on PERT, LOB, CPM and probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Other topics include network development, computer adaption, progress reports and project monitoring. Prerequisite: Knowledge of computer programming. Also listed under IE 620

MG 820 Project Management 2 ½: 0: 3
Specific managerial concepts and techniques related to management of projects in research and development, construction and engineering. Functional and administrative structures, coordination of activities, manpower planning, feasibility analysis, negotiations and contracts.
MG 825 Construction Administration 2½:0:3
Management problems unique to construction business including licensing, bonding, insurance, short-term financing, employee relations. Prerequisite: MG 600.
Also listed under CE 825

MG 825 Construction Estimates and Costs 2½:0:3
Estimates, costs from viewpoint of contractor or construction engineer, details of estimating, emphasis on labor, material, equipment, overhead costs. Prerequisite: MG 825.
Also listed under CE 825

MG 827 Specifications and Contracts 2½:0:3
Principles of contract law as applied to construction industry; legal problems in preparing and administering construction contracts. Prerequisite: MG 825.
Also listed under CE 827

MG 840 Financial Aspects of Public Policy 2½:0:3
Politics of fiscal policy and the social welfare principles. Optimality of public policy with regard to social goods, supported research and development, and different taxation methods. Effect of external economies and diseconomies on the Pareto Optimum conditions; public regulation of social resources allocation. Prerequisite: approval of instructor.

MG 850 Cost Systems 2½:0:3
Methods used in industry for predicting and recording costs. Design and operation of standard and direct cost-accounting systems. Prerequisite: MG 604.

MG 852 Legal and Regulatory Aspects of Transportation 2½:0:3
An in-depth treatment of the origins, causes and effects of regulation on transportation and society in the U.S. Economic and conditional bases for transportation regulation. The legal basis, structure and function of federal, state and local regulating bodies and their interaction with transportation industries. Current controversies concerning the deregulation of sectors of the transportation industry.
Also listed under TR 756

MG 853 Transportation Finance 2½:0:3
Material is approached with a public finance perspective, including a review of those economic theories and analytical techniques that are of particular relevance to transportation. Special attention is given to such areas as (a) the equity vs. efficiency question in transport finance; (b) general vs. ear-marked revenue methods; (c) the valid (and invalid) uses of cost-benefit and cost-effectiveness studies and (d) peak load (marginal cost) pricing.
Also listed under TR 751

MG 855 Analysis of Transportation Markets 2½:0:3
Application of the principles of marketing to public and private transportation operations. Basic market structure of major modes is reviewed to demonstrate how gaining and using market data can increase efficiency and profitability of operations. Attention is given to (a) how factors that affect modal choice are determined and (b) how this information can be integrated into a "marketing plan" that includes service, pricing, and promotional aspects.
Also listed under TR 752

MG 856 Behavioral and Sociological Aspects of Transportation 2½:0:3
Behavioral analysis of transportation decision-making and travel characteristics. Sociological factors involved in travel decisions—crime, social isolation, comfort and convenience.
Also listed under SS 195 and TR 758

MG 857 Transportation Management 2½:0:3
Management problems in the private and public transportation sectors, discussion of various types and forms of transportation organizations—planning organizations, modal operators, consulting firms, etc.—and treatment of organizational problems and issues from the managerial perspective. Private vs. public transportation operators and agencies. Public and semi-public operating authorities: legal basis, fiscal structure, purpose, interaction with private operators. Prerequisites: MG 601 and TR 660, or equivalent, or adviser's approval.
Also listed under TR 757

MG 858 Transportation Policy and Decision-Making 2½:0:3
A high-level treatment of policy formulation and decision-making in the transportation industry on several levels: federal policy, state and local policy, individual operating policies. Course uses an intensive case-study approach in a seminar or discussion format. Emphasis is on mass transit operations. Prerequisite: adviser's approval.
Also listed under TR 758

MG 860 Financial Planning, Internal Reporting and Operational Control 2½:0:3
The techniques of financial planning and control at various levels within the enterprise with emphasis on an analysis and quantifiable aspects of individual or corporate productivity. Applications in the public and private sectors. Budgeting, monitoring and evaluation of performance, "expense and investment centers," transfer pricing, relationship between control systems and organizational goals. Prerequisites: MG 604 and MG 656.

MG 862 Industrial Marketing 2½:0:3
Problems concerning the marketing of industrial products, particularly those of high technological content. Projecting consumer demand, establishing channels of distribution, sales and customer training, advertising and promotion, technical support of the marketing program and budgeting for these activities of the firm. Prerequisites: MG 600 and MG 607.

MG 863 Market Research 2½:0:3
An overview of the accepted methodology for identifying and sizing an existing or emerging market for a specific product to its guide management action in research and development, manufacturing or marketing. Techniques appropriate to collecting, analyzing and reporting market information to management are explored. Prerequisites: MG 605 and MG 607.

MG 864 Product Planning 2½:0:3
A systematic study of the process followed by successful companies in creating a commercially viable product from technology developed by or available to the firm. The steps involved up to market entry are reviewed sequentially: the initial search, preliminary evaluation, organizing the new product venture, manufacturing preparation, market testing, etc. Financial aspects of product development. Prerequisites: MG 600 and MG 607.

MG 865 Research, Development and Management of Innovation 2½:0:3
Introduction to the environment of technological growth in this country with reference to the economy and the firm. Examination of policies and factors that affect innovation in industry. Methods for assessing and forecasting technology, depth, cross-impacting scenarios, parameter extrapolation, exploring, etc. Problems in managing research and development by private enterprise during an era of rapid technological change. Prerequisite: MG 600.
MG 886 Technology Management and Policy 2½:0:3
Topics and issues in private and public management to which considerations of technology are central: strategic planning in high-technology corporations, the government's role in directing technology, defense, space, the SST and energy. Managing the large-scale technological enterprise. Science and technology in international relations. Prerequisite: MG 600

MG 912 Seminar in Investment Analysis 2½:0:3
Financial markets and individual and corporate investment decisions. Study of theories of market efficiency and investment strategy. Risk analysis, portfolio theory, technical and fundamental assessments. Implications of national and international economic forces, such as business cycles, currency markets, and profit repatriation restrictions, for individual and corporate investment decisions. Prerequisites: MG 600 and MG 606, or permission of instructor.

MG 940 Joint Project or Internship in Transportation Management 3 units
An independent project or internship in transportation management for students enrolled in the joint M.S. program in Transportation Management. Also listed under TR 940

MG 963 Seminar in Financial Planning and Control 2½:0:3
Capital budgeting and investment valuation under certainty and uncertainty. Application of portfolio theories and mathematical programming to corporate investment alternatives. Management of alternative sources of capital and cash flow. Short- and long-term financial management and control. Implications of national and international political and economic forces, such as interest rates, transfer prices, tariffs, business cycles, currency markets, and profit repatriation restrictions, for corporate decisions about sources and uses of capital. Prerequisites: MG 603 and MG 606, or permission of instructor.

MG 970 Business Policy and Strategy 2½:0:3
Integration of functional disciplines studied in the master's program to understand how organizations are managed strategically. The "top management" perspective is the focus. Setting organizational goals, establishing policies that assure realization of objectives, devising and implementing strategies to gain competitive advantage or capitalize on a corporate opportunity. Cases, research paper. Prerequisite: advanced standing.

MG 975 Selected Topics in Management 2½:0:3
Current topics in various fields analyzed and discussed. Prerequisite: advanced standing and permission of instructor.

MG 976-977 Readings in Management 3 units
Directed individual study or supervised readings in advanced areas of management. Prerequisite: permission of dean.

MG 985 Selected Topics in Organizational Behavior 2½:0:3
Discussion and analysis of current topics in organizational behavior. Prerequisite: advanced standing and permission of instructor.

MG 986-987 Readings in Organizational Behavior 3 units
Directed individual study or supervised readings in advanced areas of organizational behavior. Prerequisite: permission of dean.

MG 997 Thesis for Degree of Master of Science 3 units
Original investigation in topic chosen by student. Conferences and progress reports required during work, and final written report required at completion. Oral examination may be requested by department. Registration and degree credit beyond first six units require separate approval. Prerequisites: degree status and approval of supervising professor, adviser and division dean.

FACULTY

Richard W. Sonnenfeldt, Professor of Management and Dean of Management
B.S.E.E., The Johns Hopkins University
Management of high technology business

John T. Chu, Professor of Operations Research and Management Science
B.S., University of Chekiang (China); M.S., Ph.D., Iowa State University
Managerial decisions, behavioral approach, national and international affairs

Norbert Hauser, Professor of Industrial Engineering and Management Science Academic Chairman
B.M.E., Cooper Union; M.I.E., Eng. Sc. D., New York University
Modeling of social systems, computer simulation, quality control

Anthony J. Wiener, Professor of Management
A.B., J.D., Harvard University
Long-range planning, public policy studies, political, economic and social environment of business, technology management and assessment

Seymour Kaplan, Associate Professor of Operations Research and Management Science
B.S., Newark College of Engineering; M.S., Ph.D., New York University
Economic modeling, linear programming

Harold G. Kaufman, Associate Professor of Management, Director of Organizational Behavior Program
B.M.E., Cooper Union; M.I.E., Ph.D., New York University
Career management, science and engineering manpower, obsolescence and continuing education

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management, Co-Director of Operations Management Program
B.S., Banaras Hindu University (India); M.S., Ph.D., University of Illinois
Production and operations planning, productivity analysis, project control

A. George Schilling, Associate Professor of Management and Operations Research
B.E.E., CCNY, MS, Eng. S.D., Columbia University
Technology management, policy studies, stochastic systems

Melvyn L. Meer, Assistant Professor of Management
A.B., Brooklyn College, Ph.D., University of Minnesota
Economic models and forecasting, financial planning and management, public policy and management
David A. Schrier, Assistant Professor of Management, Co-Director of Management Program, Director of Operations Management Program. B.S., Florida State University; M.B.A., D.B.A., George Washington University. 

Organization development and training

Thomas Conoscenti, Academic Associate, Program Director, Farmingdale Campus. B.S., M.A., Ph.D., New York University. Economics, statistics, public policy.


Subash C. Midha, Academic Associate. M.B.A., M.S., State University of New York at Buffalo. Accounting, finance, cash management.

ADJUNCT FACULTY

Gerard P. Gorman, Adjunct Professor. B.S., Pratt Institute; M.S., New York University.

Paul Lerman, Adjunct Professor. B.A., M.S., Ph.D., New York University.

Lawrence M. Parks, Adjunct Professor. B.S., M.S., Ph.D., Polytechnic Institute of New York.

Jerry M. Rosenberg, Adjunct Professor. B.S., City College of New York; M.A., Ohio State College; Ph.D., New York University.

Robert J. Burton, Adjunct Associate Professor. B.A., City College of New York; J.D., Stanford University.

Byron L. David, Adjunct Associate Professor. B.A., Queens College of City University of New York; M.S., Polytechnic Institute of New York.

Stanley J. Jacoby, Adjunct Associate Professor. B.S., Polytechnic Institute of New York; M.S., Columbia University; M.M.S., Stevens Institute of Technology; PE.

Steven Kolman, Adjunct Associate Professor. B.S., M.B.A., New York University.

Karle S. Packard, Adjunct Associate Professor. A.B., Columbia College; M.S., New York University; M.S., Polytechnic Institute of New York.

Herbert Schiller, Adjunct Associate Professor. B.S., Polytechnic Institute of New York; M.S., California Institute of Technology.

Andrew Sipos, Adjunct Associate Professor. Engineering Diploma, Technical University, Budapest; M.S.C.E., University of Pennsylvania.

William M. Abrams, Adjunct Assistant Professor. B.B.A., CCNY; CPA.

David Brawerman, Adjunct Assistant Professor. B.B.A., Bernard M. Baruch College.

Thomas A. Dougherty, Adjunct Assistant Professor. B.S., Fairleigh Dickinson; CPA.

George T. Hoffman, Adjunct Assistant Professor. B.B.A., St. John's University; M.B.A., Adelphi University.

David J. Kramer, Adjunct Assistant Professor. B.E.M.T., The City College of New York; M.S., Polytechnic Institute of New York.

Mark Kurman, Adjunct Assistant Professor. B.A., New York University; M.A., Bowling Green State University.

Irwin Sponder, Adjunct Assistant Professor. B.S., Long Island University; M.S., C.W. Post College.

Peter Wan, Adjunct Assistant Professor. B.S., Taiwan Chung Yuan; M.S., Kansas State University.

Kenneth M. Rubin, Adjunct Instructor. B.B.A., Baruch College; M.B.A., St. John's University.

Amadee Bender, Lecturer. B.A., C.W. Post College; M.B.A., New York University.


Joel H. Joseph, Lecturer. B.A., Yale University; J.D., Hofstra University.

Mark Presser, Lecturer. B.S., University of New York at Albany; M.S., Ph.D., Rensselaer Polytechnic Institute.

COOPERATING POLYTECHNIC FACULTY

Edward S. Cassedy, Professor of Electrical Engineering.

Walter Heilly, Professor of Operations Research.

John H. K. Kao, Professor of Industrial Engineering.

Joachim I. Weindling, Professor of Operations Research and System Engineering.

Lester O. Bumas, Associate Professor of Economics.

Herman Grau, Associate Professor of Industrial Engineering.

Vincent K. Omachonu, Instructor of Industrial Engineering and Operations Management.
Mathematics is a branch of learning devoted to the solution of problems by the use of symbolic language and formal logical operations. It serves as a foundation for other scientific disciplines and is an indispensable tool for engineering. Today mathematicians find employment not only in schools and colleges but in every branch of industry and government as well.

A complete spectrum of mathematics courses is offered at Polytechnic ranging from first-year courses to the doctoral level and covering all branches of abstract and applied mathematics.

In addition, a sequence of elective courses is available in theoretical and applied statistics that enables students to prepare themselves for a career in statistics or in a field utilizing statistical theory and techniques. The graduate curriculum is more specialized. Course work, thesis work and informal departmental activities are all designed to familiarize students with the field of mathematics in general, while they become specialists in the particular area of their choice.

UNDERGRADUATE PROGRAM

The undergraduate program in mathematics provides both a background for advanced study and subsequent research in abstract and applied mathematics and training for those students who expect to terminate their formal education with the bachelor's degree. In addition, a sequence of elective courses in theoretical and applied statistics enables a student to prepare for a career in statistics or in a field utilizing statistical theory and techniques.

For the science and engineering major, mathematics courses provide the theory and methods essential for the comprehension of the mathematical aspects of their respective fields.

In accordance with these objectives, the Department of Mathematics offers a variety of courses in abstract and applied mathematics and, for the mathematics major, specific programs leading to the degree of bachelor of science.

Students wishing to pursue the bachelor's degree in mathematics may elect to follow either of the two courses of study. Students wishing to focus their studies within mathematics itself may elect course of study I, emphasizing abstract mathematics (see page 3 of this section). Students particularly interested in applying mathematical knowledge and techniques to other fields may elect course of study II, emphasizing applied mathematics (see page 4 of this section). Both programs provide basic grounding in mathematical knowledge. Details of each program follow.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 111-114 or MA 101-104, 153, 154, 217, 223, 333</td>
<td>29</td>
</tr>
<tr>
<td>CS 111, PH 101-103, CM 101, 102, 111, 112</td>
<td>19</td>
</tr>
<tr>
<td>HU 101, and HU 200, SS 104 or IS 140, IS 141</td>
<td>9</td>
</tr>
<tr>
<td>Two years (or equivalent) of French, German, Russian or Spanish*</td>
<td>12</td>
</tr>
<tr>
<td>Major specialty†</td>
<td>18</td>
</tr>
<tr>
<td>Minor Specialty‡</td>
<td>12</td>
</tr>
<tr>
<td>Humanities/Social Sciences electives</td>
<td>9</td>
</tr>
<tr>
<td>Free electives§</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>128</strong></td>
</tr>
</tbody>
</table>

Options—in order to qualify for a New York State Teacher's Certificate in Mathematics, a student may have a maximum of 18 credits in courses in education accepted for transfer credits in place of the corresponding number of free elective credits. ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101-104 (physical education); juniors and seniors may substitute three of the following two-credit courses: MS 301, 303, 401 or 403, for six credits of technical electives.

* If less than 12 credits are needed, the remaining credits should be taken in the humanities/social science areas.
† Major specialty: Students must elect a coherent course of study in their major field; two typical selections follow.
‡ Minor specialty: at least twelve credits beyond the required course in any single area of study outside the Department of Mathematics, except for statistics, which may include mathematical statistics courses.
$ Students may choose the pass/fail grade option for free elective courses.
The Minor Specialty — In order to achieve some depth of understanding in a field other than mathematics, the student is asked to choose a 12-credit sequence from another discipline. This work must be in addition to courses taken under other categories of the program; e.g., required courses in physics do not count toward a minor in physics nor do French courses offered to fulfill the language requirement count toward a minor in French. With the exception of applied statistics and computing courses, all minor course work must be completed outside the department. Education courses will not be accepted toward a minor specialty nor will the first two years of a second foreign language.

Minor in Computer Utilization — The applied mathematics major offers an excellent opportunity for the inclusion of a minor in computer utilization. This minor combines a substantial amount of computer software and hardware knowledge such as that included in normal computer science and computer engineering curricula. However, the emphasis in the computer utilization minor is on the application of computers to industrial, business, and government needs. These needs employ the techniques of applied mathematics, statistics, and numerical analysis that are provided by the mathematics curriculum.

The courses of the minor specialty will be chosen in consultation with an adviser. In appropriate cases, the adviser for the minor sequence may be from a department other than mathematics. The following are examples of possible minor concentrations:

<table>
<thead>
<tr>
<th>Aerospace</th>
<th>AM 111, 112, 311, 312</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Statistics</td>
<td>MA 224, 232, 555, 556, 557</td>
</tr>
<tr>
<td>Biology</td>
<td>LS 105, 115, 105, 116, 103</td>
</tr>
<tr>
<td>Chemistry</td>
<td>CM 122, 123, 161, 162</td>
</tr>
<tr>
<td>Computers</td>
<td>CS 203, 205, 236, 237</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>IE 300, 306, 327, and one of IE 311, 318, 321</td>
</tr>
<tr>
<td>Operations Research</td>
<td>IE 300, 327, 328, and one of IE 319, 346, 380</td>
</tr>
<tr>
<td>Management</td>
<td>MG 300, SS 199, IE 252 and either SS 251 or SS 252</td>
</tr>
<tr>
<td>Physics</td>
<td>PH 210, 321, 313, 314</td>
</tr>
<tr>
<td>Psychology</td>
<td>SS 189, 190, 192, 193, 195, 197</td>
</tr>
<tr>
<td>Economics</td>
<td>SS 251, 252, 270, IE 300</td>
</tr>
<tr>
<td>Electrical Engineering Systems</td>
<td>EE 101, 102, 103, 104</td>
</tr>
<tr>
<td>English Literature</td>
<td>HU 211, 212, 222, 241, 251, 256, 262, 272, 295</td>
</tr>
<tr>
<td>French</td>
<td>ML 135, 235, 236, 237, 238</td>
</tr>
<tr>
<td>Transportation</td>
<td>TR 360, 361, 362, 840, 842, 845</td>
</tr>
</tbody>
</table>

Advanced Placement — Advanced placement credit may be given for the first year of calculus. A student receiving a grade of 4 or 5 on the advanced placement examination in calculus, conducted by the College Entrance Examination Board, will be granted eight credits that may be applied toward the 128-credit requirement for the bachelor’s degree in mathematics.
Typical Course of Study I for the Bachelor of Science Degree in Mathematics (Abstract)

Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>MA 111</td>
<td>Calculus Ia</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>PH 101</td>
<td>General Physics I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CS 111</td>
<td>Intro. to Computing</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>HU 101</td>
<td>College Composition</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Language courses</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sophomore Year

| MA 113 | Calculus IIa | 3 | 0 | 3 | MA 114 | Differential Equations | 3 | 0 | 3 |
| MA 154 | Elem. Abstract Algebra | 3 | 0 | 3 | MA 570 | Intro. Geometry | 3 | 0 | 3 |
| PH 103 | General Physics III | 2½ | 1½ | 3 | CM 102 | General Chemistry II | 2½ | 0 | 2½ |
| Language course | 3 | 0 | 3 | CM 112 | General Chemistry Lab. II | 0 | 1½ | ½ |
| CM 101 | General Chemistry I | 2½ | 0 | 2½ | Language course | 3 | 0 | 3 |
| CM 111 | General Chemistry Lab. I | 0 | 1½ | ½ | Electives* | 3 |
| PE 103 | Physical Education | 0 | 2 | 0 | PE 104 | Phys. Ed. | 0 | 2 | 0 |
| **Total** | **15** | | | | **Total** | **15** |

Junior Year

| MA 211 | Analysis I | 3 | 0 | 3 | MA 212 | Analysis II | 3 | 0 | 3 |
| MA 217 | Complex Variables | 3 | 0 | 3 | MA 333 | Partial Diff. Equations | 3 | 0 | 3 |
| MA 223 | Intro. to Probability | 3 | 0 | 3 | Minor specialty† | 3 |
| SS 104 | Contemp. World History | 3 | 0 | 3 | Electives* | 7 |
| Minor Specialty | 3 | | | | | **Total** | **16** |
| Electives* | 13 | | | | | **Total** | **16** |

Senior Year

| Minor specialty | 3 | Minor specialty† | 3 |
| Electives | 13 | Electives* | 13 |
| **Total** | **16** | **Total** | **16** |

Total credits required for graduation: 128

*Electives total 45 credits, of which at least nine must be in the courses with MA labels and at least nine in courses with HU, SS or ML labels. Remaining elective may be freely chosen from the catalog.

†See minor specialty
Typical Course of Study II for the Bachelor of Science Degree in Mathematics (Applied)

Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 111 Calculus I</td>
<td>4 0 4</td>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 General Physics I</td>
<td>3 0 3</td>
<td>PH 102 General Physics II</td>
<td>3 1/2 1 1/2 4</td>
</tr>
<tr>
<td>CS 111 Intro. to Computing</td>
<td>3 0 3</td>
<td>HU 200 Intro. Western Lit.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>HU 101 College Composition</td>
<td>3 0 3</td>
<td>SS 104 Contemp. World History</td>
<td>3 0 3</td>
</tr>
<tr>
<td>Language courses</td>
<td>3 0 3</td>
<td>Language course</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE 101 Physical Education</td>
<td>0 2 0</td>
<td>PE 102 Phys. Ed.</td>
<td>0 2 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td><strong>Total</strong></td>
<td>17</td>
</tr>
</tbody>
</table>

Sophomore Year

| | | |
| MA 103 Calculus III | 3 0 3 | MA 104 Appl Diff. Equations | 3 0 3 |
| PH 103 General Physics III | 2 1/2 1 1/2 3 | MA 224 Intro. to Math. Stat. | 3 0 3 |
| MA 223 Intro. Probability | 3 0 3 | MA 153 Elem. of Linear Algebra | 3 0 3 |
| Language course | 3 0 3 | Language course | 3 0 3 |
| CM 101 General Chemistry I | 2 1/2 0 2 1/2 | CM 102 General Chemistry II | 2 1/2 0 2 1/2 |
| CM 111 General Chemistry Lab. I | 1 1/2 1/2 | CM 112 General Chemistry Lab. II | 0 1 1/2 1/2 |
| PE 103 Physical Education | 0 2 0 | PE 104 Phys. Ed. | 0 2 0 |
| **Total** | 15 | **Total** | 17 |

Junior Year

| | | |
| MA 201 Applied Analysis I | 3 0 3 | MA 202 Applied Analysis | 3 0 3 |
| MA 217 Complex Variables | 3 0 3 | MA 358 Intro. Numerical Anal. | 3 0 3 |
| MA 333 Partial Diff. Equations | 3 0 3 | IE 328 Operations Res. Models II | 3 0 3 |
| IE 327 Operations Res. Models I | 3 0 3 | Minor specialty | 3 |
| Minor Specialty* | 3 | Electives | 4 |
| Electives | 2 | **Total** | 16 |
| **Total** | 17 | **Total credits required for graduation**: 128 |

Senior Year

| | | |
| MA 154 Elem. of Abstract Algebra | 3 0 3 | Minor specialty | 3 |
| Minor Specialty* | 3 | Electives | 13 |
| Electives | 10 | **Total** | 16 |
| **Total** | 16 |

* See minor specialty

GRADUATE PROGRAMS

The Department of Mathematics offers graduate-level courses in the fields of foundations and logic, analysis, geometry and topology, algebra and number theory, applied mathematics, probability and statistics. These courses form a major portion of the work for advanced degrees in mathematics. They may also be taken by students in other departments to satisfy minor and elective requirements and by qualified pre-degree students who desire further study in graduate-level mathematics.

The department offers the master's degree in the fields of abstract mathematics, industrial and applied mathematics, applied statistics and mathematics teaching at the high school level. A bachelor's degree in mathematics is required for admission to this program. Students with degrees in other fields may be admitted, possibly with undergraduate deficiencies, at the discretion of the departmental adviser.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN MATHEMATICS (ABSTRACT)

A bachelor's degree in mathematics is required for admission to this program. Students with degrees in other fields may be admitted, possibly with undergraduate deficiencies, at the discretion of the departmental adviser.
Before beginning graduate study, the student is expected to have completed a year's course in advanced calculus. In case of acceptance without these credits, the student will be asked to take the sequence MA 619-620 at Polytechnic in addition to the other requirements listed below for a master's degree.

Thirty-six units are required, including 21 units of required courses. If the student elects, six units may be devoted to a thesis.

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 621-622</td>
<td>Real and Complex Analysis</td>
<td>6</td>
</tr>
<tr>
<td>MA 705-706</td>
<td>Linear and Modern Algebra</td>
<td>6</td>
</tr>
<tr>
<td>Elective courses</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Additional electives or thesis</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>36</td>
</tr>
</tbody>
</table>

The thesis option includes an examination of the thesis material by the student's faculty adviser and certification that the work is satisfactory. A student offering only course work must pass a comprehensive oral examination before the degree is awarded. This examination covers the student's program of study and is scheduled toward the end of the semester in which the work will be completed.

**REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE (STATISTICS)**

A bachelor's degree is required in some quantitative field with at least a minor in mathematics, which should include a six-credit course in probability and statistics equivalent to MA 233-224 or MA 561-562. The student is also expected to have a working knowledge of FORTRAN and/or PL 1 programming language. A student may be admitted with undergraduate deficiencies after consulting with the departmental adviser. Such a student will be required to take the courses necessary to remove the deficiencies.

**Required Courses**

1. MA 619-620 Advanced Calculus 6
2. MA 554 Applied Decision Theory 3
3. MA 555 Design of Experiments 3
4. MA 556 Correlation and Multivariate Models 3
5. MA 557 Sampling 3
6. MA 853 Probability 3
7. MA 855 Stochastic Processes 3
8. MA 861 Principles of Statistical Inference 3
9. MA 862 Inference I, II 3

**Electives**

1. Project ST 995 (3 units) 3
2. Thesis ST 997 (6 units) 6

**Total** 36

Regulations governing the thesis option or final examination for this degree are the same as for the master's degree in mathematics.
REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN MATHEMATICS EDUCATION

A bachelor's degree in mathematics is required for admission to this program intended for teachers of mathematics in grades 7-12. Students with degrees in other fields may be admitted, possibly with undergraduate deficiencies, at the discretion of the department adviser. Acceptable mathematics courses are numbered 500 and above; the program should be approved by the departmental adviser.

MA 931-932  Selected Topics in the Teaching of Mathematics  6
Elective courses in mathematics  18
Electives (additional mathematics, history of science, psychology, etc.)  6
MA 996 Project  6

36

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN MATHEMATICS

Within the Department of Mathematics, Polytechnic offers graduate study in the field of statistics leading to the Ph.D. degree. A full range of courses is offered in the areas of applied and mathematical statistics, supported by a range of elective courses in probability and all areas of abstract and applied mathematics. Students may also take elective courses from other departments, selected under the supervision of their graduate adviser.

A bachelor's degree with at least a minor in mathematics, which should include a one-year course in advanced calculus, is required. A working knowledge of FORTRAN and/or PL 1 programming language is also desirable.

No.  Required Subjects  Units
MA 630  Elements of Complex Variables  3
MA 703  Linear Algebra  3
MA 621  Real Analysis  3
MA 835,855  Probability, Stochastic Processes  6
MA 861-862  Principles of Statistical Inference  6
MA 863-864  Multivariate Analysis  6
MA 865-866  Regression and Analysis of Variance  6

33

At least 3 of
MA 555  Design of Experiments
MA 557  Sampling
MA 867  Nonparametric Methods in Statistics
MA 881  Statistical Analysis of Time Series

Electives, approved by departmental adviser  27-30
Subtotal  72
Dissertation ST 999 (3 units each)  24
Total  96

The student must satisfy the doctoral language requirements in one language selected from French, German or Russian.

REQUIREMENTS FOR CERTIFICATE PROGRAMS

The department offers certificate programs in the areas of applied statistics, mathematical statistics, computer mathematics and mathematical programming. Requirements for the certificate program are 15 units.

Applied Statistics
MA 223  Introduction to Probability
MA 224  Introduction to Mathematical Statistics
Choice of three
MA 863 Multivariate Analysis I
MA 864 Multivariate Analysis II
MA 865 Regression and Analysis of Variance I
MA 866 Regression and Analysis of Variance II
MA 881 Statistical Analysis of Time Series I
MA 892 Statistical Analysis of Time Series II
MA 867 Nonparametric Methods in Statistics

Computer Mathematics
MA 821 Numerical and Approximate Analysis I
MA 822 Numerical and Approximate Analysis II

Choice of three
MA 823 Special Topics in Numerical Analysis I
MA 825 Numerical Linear Algebra
MA 837 Applied Matrix Theory
MA 838 Linear Algebra and Differential Equations

Mathematical Programming
MA 812 Theory of Games
MA 813 Linear Programming

Choice of three
MA 814 Integer Programming
MA 817 Graph Theory
MA 818 Nonlinear Programming
MA 844 Optimal Control Theory

UNDERGRADUATE COURSES

MA 001 Pre-Collegiate Algebra 2:0:nc
For the student who has not taken this subject in preparatory school or who needs review work in algebra. Exponents and radicals, factoring and fractions, logarithms, systems of equations, ratio, proportion, variation, quadratic equations, inequalities.

MA 005 Pre-Collegiate Trigonometry 2:0:nc
For the student who has not taken this subject in preparatory school or who needs review work in trigonometry. Definitions of trigonometric functions, reduction formulas, radian measure and curve plotting, addition and subtraction formulas, inverse trigonometric functions, solutions of trigonometric functions, solutions of trigonometric equations, polar coordinates.

MA 011 Review of Calculus 2:0:nc
For graduate students who are insufficiently prepared for subsequent required courses in differential equations. Fundamental concepts and applications of calculus and infinite series. Course is remedial, and admission requires recommendation of departmental adviser.

MA 091-092 Principles of Mathematics I, II each 4:0:4
Logic, sets, mathematical induction, geometry, trigonometric functions, limits, differentiation, integration and some applications, probability. First course in mathematics for students in Departments of Humanities and Social Sciences.

MA 101 Calculus I 4:0:4
Standard first course in calculus for beginning students. Function concept, trigonometric functions, limits of algebraic and trigonometric functions, differentiation, maximization, applications to geometry and physics. The integral, elementary techniques of integration of algebraic and trigonometric functions.

MA 102 Calculus II 4:0:4
Applications of integration, logarithmic and exponential functions, advanced techniques of integration, hyperbolic functions, inverse trigonometric and hyperbolic functions, areas in polar coordinates, conic sections, indeterminate forms, infinite series and power series.

MA 103 Calculus III 3:0:3
Solid geometry and vectors, partial derivatives. Parametric equations. Prerequisite: MA 102 or MA 112.

MA 104 Applied Differential Equations 3:0:3
Ordinary differential equations, separable variables, linear equations with constant coefficients, series solutions. Systems of differential equations. Prerequisite: MA 102 or MA 112.

MA 111 Calculus I 4:0:4
First course in calculus with emphasis on definitions and proofs. Standard operations of calculus of one variable, differentiation formulas, applications. The integral, methods of integration, applications. Polar coordinates, parametric equations, plane curves. Elementary transcendental functions. Prerequisite: department's permission.

MA 112 Calculus II 4:0:4
Sets and sequences of real numbers, properties of a real number system. Theory of limits and continuity. Definition of Riemann integral and Riemann-Stieltjes integral. Vectors on plane and space. Determinants. Introduction to matrices. Prerequisite: MA 111 or MA 101 and department's permission.

MA 113 Calculus III 3:0:3

MA 114 Differential Equations 3:0:3

MA 143 Introduction to Number Theory 3:0:3
Properties of integers and prime numbers, congruences, theorems of Fermat, Euler, Wilson, quadratic residues, diophantine equations. Prerequisite: MA 102.

MA 153 Elements of Linear Algebra 3:0:3
Linear transformations, matrices and determinants, characteristic roots, diagonalization, introduction to vector spaces. Prerequisite: MA 102 or MA 112.

MA 154 Elements of Abstract Algebra 3:0:3
Basic properties of groups, rings, fields, ideals, Euclidean rings, modules, field extension, Galois theory, finite fields, finite division rings. MA 154 prerequisite: MA 153.
MA 161 Introduction of Point Set Topology 3:0:3
Definition of topology and topological space, mappings, compact sets, separation axioms, metric space and completion of a metric space. Prerequisite: MA 211 or MA 202.

MA 177† Transformation Geometry 3:0:3
Reflections, congruence, groups, homogeneous spaces, isometries, group of similarities, circular transformations. Hyperbolic and elliptic geometry. Prerequisite MA 211 or MA 202.

MA 178† Projective Spaces 3:0:3
Incidence structure, configuration theorems, partial projective planes, finite projective spaces, conics. Prerequisite: MA 211 or MA 202.

MA 194† History of Mathematics 3:0:3
Historical study of fundamental ideas of mathematics from antiquity to present day. Designed to develop deeper understanding of and cultural appreciation for significance of mathematics in civilization. Prerequisite: MA 102.

MA 201-202 Applied Analysis each 3:0:3
Study of basic topics in analysis with emphasis on methods. Sequences, series, functions, uniform convergence, continuity, partial differentiation, extreme value problems with constraints, Riemann integrals, line integrals, improper integrals, integrals with parameters, transformations, Riemann-Stieltjes integrals, uniform and absolute convergence of integrals, Beta, Gamma functions. Prerequisites: MA 103 and MA 104.

MA 211-212 Analysis I, II each 3:0:3
Careful and rigorous discussion of real numbers. Limits, sequences, series. Functions of one real variable: continuity, derivatives, integrals. Continuation of MA 211. Sequences and functions of one variable: Functions of several variables; transformations. Theorems of Gauss, Green, Stokes. MA 211 prerequisite. MA 114. MA 212 prerequisite. MA 211.

MA 217 Complex Variables 3:0:3
Functions of complex variables, derivatives, Cauchy-Riemann equations, integrals, Cauchy integral theorem, power series, residue theory, conformal mapping, Schwarz-Christoffel transformation. Prerequisites: MA 103 and MA 104.

MA 223† Introduction to Probability 3:0:3
Standard first course in probability, recommended for those planning further work in probability or statistics. Probability of events, random variables and expectations, discrete and continuous distributions, joint and conditional distribution, moment generating functions, central limit theorem. Prerequisite: MA 103.

MA 224† Introduction to Mathematical Statistics 3:0:3
Standard first course in mathematical statistics, recommended for those planning to take advanced work in statistics. Sampling distributions, tests of hypotheses, significance tests, point and interval estimation, regression and correlation. Prerequisite: MA 223 or MA 561.

MA 231† Statistical Methods I 3:0:3

MA 232† Statistical Methods II 3:0:3
Analysis of variance with simple experimental designs. Sampling procedures, including sequential analysis. Nonparametric statistical methods. Statistical decisions. Prerequisite: MA 231 or MA 562 or MA 224.

MA 238† Applied Probability 3:0:3
Second course in probability with emphasis on applications. Topics chosen from reliability theory, sampling theory, Monte Carlo methods, combinatorial analysis. Prerequisite: MA 231.

MA 239† Mathematical Modeling 3:0:3

MA 260† Vector Analysis and Partial Differential Equations

MA 333 Partial Differential Equations 3:0:3

MA 341 Discrete Computational Structures I 3:0:3
Topics in discrete mathematics for computer science and engineering. Counting methods for arrangements and selections, generating functions, and recurrence relations. Set theory methods of enumeration. Topics from linear graphs and networks. Prerequisite: junior status or permission of instructor.

MA 342 Discrete Computational Structures II 3:0:3
Continuation of MA 341 with applications of combinatorial mathematics, algorithms involving discrete optimization, queuing theory in computer science. Prerequisite: MA 341.

MA 358 Introductory Numerical Analysis 3:0:3
Numerical solution of equations, difference tables, linear differences, operator methods, numerical differentiation and integration, numerical solution of ordinary differential equations, systems of linear equations, solution by direct and iterative methods. Prerequisites: MA 104. MA 153 and some experience in programming for digital computers.

MA 385-386 Reading Seminar in Mathematics I, II 3:0:3
Reading, study and investigation of selected topics in mathematics. Problem discussion and presentation by participating students. Prerequisite: department advisor's permission.

Additional offerings in the area of statistics may be found under 500-number courses.

GRADUATE COURSES

MA 531-532† Applied Mathematics in Engineering and Science, I, II each 2½:0:3
MA 535 Vector and Tensor Analysis 2½:0:3
Vector analysis in three dimensional space, integral theorems, applications to potential theory. Tensor algebra, tensor calculus, fundamentals of Reimannian geometry, divergence theorem. Applications of tensor calculus to the calculus of variations and field theories of relativity. Prerequisite: MA 103 and 153 or equivalent.

MA 541-542 Fundamentals of Discrete Mathematics I, II each 2½:0:3
Mathematical models, mathematical reasoning, primitives of naive set theory, inductive and recursive procedures, functions, relations, ordinal/ration, introduction to graph theory, counting and algorithm analysis, introduction to algebraic structures. MA 541 prerequisite: permission of adviser. MA 542 prerequisite: permission of adviser. (May be taken for graduate credit by graduate students in the Department of Mathematics.)

MA 551† Applied Statistics I (Data Analysis) 2½:0:3
Treatment of statistical methods and application to analysis of data, to fitting of functions to data. Estimation of population parameters. F tests, chi-square tests, rank tests, analysis of variance, linear and non-linear regression, spectral analysis. Prerequisite: calculus

MA 552‡ Applied Statistics II (Experimental Design) 2½:0:3
Statistical principles useful in designing comparative and descriptive experiments and their application. Randomized block designs, latin square, factorial, saturated response surface designs, sequelietal experimentation. Prerequisite: MA 551 or MA 232.

MA 554† Applied Decision Theory 2½:0:3
Principles of statistical decision procedures, introduction to utility theory, minmax, Bayes strategies. Applications to problems in engineering, science, management. Prerequisite: MA 224 or MA 562.

MA 555† Design of Experiments 2½:0:3
Principles of modern statistical experimentation and practice in use of basic designs for scientific and industrial experiments. Single-factor experiments, randomized blocks, Latin squares, factorial and fractional factorial experiments, surface fitting designs. Prerequisite: MA 224 or MA 232.

MA 556† Correlation and Multivariate Models 2½:0:3
Treatment of exponential data involving several types of measurements per individual. Regression and correlation. Simple multiple and partial correlations. Problems of discrimination and classification, elements of factor analysis. Application to analysis and interpretation of data. Prerequisite: MA 224 or MA 232.

MA 557 Sampling 2½:0:3
Statistical theory and methods applicable to survey sampling. Simple random sampling, stratified, cluster double and systematic sampling, ratio and regression estimates, purposive sampling. Control of errors, costs and non-sampling aspects of survey investigations. Prerequisite: MA 224 or MA 232.

MA 559-559 Topics in Geometric Optimization I, II each 2½:0:3
Topics to be chosen from: search techniques, geometric distributions, packings and coverings, arrangements and circle packing, curve fitting and pattern recognition, mathematical stereology and extremum problems. MA 558 prerequisite: MA 103 and MA 104. MA 559 prerequisite: MA 103 and MA 104. (May be taken for graduate credit in the Department of Mathematics.)

MA 561† Elements of Probability 2½:0:3
Probability of events. Random variables and expectations, discrete and continuous distributions, important standard distributions and applications, moment generating functions, central limit theorem. Not acceptable for graduate credit in Department of Mathematics. (Not open to students who have taken MA 223 or equivalent.) Prerequisite: MA 103.

MA 562† Statistics 2½:0:3
Estimation, confidence limits, tests of hypothesis, regression analysis. Applications to engineering problems. Use of BMD and SPSS program packages. (Not open to students who have taken MA 224.) Not acceptable for graduate credit in Department of Mathematics. Prerequisite: MA 561.

Also listed under IE 608

MA 565‡ Intermediate Differential Equations 2½:0:3
Solution of ordinary differential equations. Applications to geometry and physics. Oscillation theory. Introduction to geometric theory, elementary critical points. Prerequisites: MA 103 and MA 104

MA 570† Introductory Geometry 2½:0:3
First course in modern geometry. Surface areas, volumes, transformation groups, convexity, Minkowski spaces, elementary metric spaces. Prerequisite: MA 113 or MA 103, and MA 153.

MA 575 Introduction to Differential Geometry 2½:0:3
Differential geometry in the plane, theory of filled gears. Introduction to transformation groups. Space curves and surfaces. Tensors and exterior forms, manifolds and tensor fields. Theory of surfaces. Introduction to Riemannian geometry. Prerequisites: MA 103 and 153 or equivalent.

LOGIC AND FOUNDATIONS

MA 603 Symbolic Logic 2½:0:3
Formal, manipulative, symbolic logic. Russell's theory of types, existence and universal quantification, material implication and equivalence. Consistency. Prerequisites: MA 103 and MA 104.

MA 605-606 Topics in Analysis for Teachers I, II each 3½:0:4½
Elements of abstract spaces and structures with applications to specific modern problems in ordinary and partial differential equations, probability and statistics, linear programming. Designed to provide high school teachers with modern concepts to enrich their classrooms. Credit for these courses granted only to those students in high school teachers' program MA 605 prerequisite: calculus. MA 606 prerequisite MA 605.

MA 607-608 Fundamentals of Mathematics I, II each 2½:0:3
Designed to modernize overall viewpoint of secondary school teachers of mathematics. Implication for secondary school curriculum derived from study of sets, topology, transformations, types of geometry. Discussions of symbolic logic and deduction, algebraic structures, analysis, probability and statistical inference, selected related topics. Prerequisite: calculus.

Also listed under IE 608

ANALYSIS

MA 619-620 Advanced Calculus I, II each 2½:0:3

MA 621 Real and Complex Analysis I 2½:0:3
Cardinal numbers, topology of n-dimensional Euclidean space, introduction to measure theory, Lebesgue integration theory, measurable functions, functions of bounded variation, absolutely continuous functions, differentiation and convergence theorems, Radon-Nikodym theorems, Luzin's theorem, product measure, Fubini theorems. Prerequisite: MA 620 or equivalent.

MA 622 Real and Complex Analysis II 2½:0:3
Rigorous development of theory of functions of complex variable. Complex number system, differentiation and integration, analytic and meromorphic functions, residue theory, introduction to Riemann surfaces, conformal mappings, Blaschke products, Picard theorems. Prerequisite: MA 621.

MA 625-626 Measure and Integration Theory I, II each 2½:0:3
General measure spaces, abstract integral and its properties, signed and complex measures, product measures, measurable transformations, measures in locally compact topological spaces, measure and topology in groups. Haar measure, measures in functional spaces. MA 625 prerequisite: MA 624 or instructor's permission. MA 626 prerequisite: MA 625.

MA 630 Elements of Complex Variables 2½:0:3
Emphasis on analytic functions of single complex variable. Complex numbers, differentiation and integration, line integrals, Cauchy integral theory, power series, residues, brief introduction to multiple-valued functions. Acceptable for graduate credit only in departments other than mathematics. Prerequisites: MA 103 and MA 104. Use of BMD and SPSS program packages. (Not open to students who have taken MA 224.)

MA 637-638 Topics in Complex Variables each 2½:0:3
Content of course varies. In spring of year prior to one in which course is offered, detailed description posted and mailed to all graduate mathematics students. MA 637 prerequisite: MA 622.

MA 645 Theory of Ordinary Differential Equations 2½:0:3
Ordinary differential equations Existence and uniqueness theorems, linear systems, isolated singularities, self-adjoint eigenvalue problems, geometric theory of differential equations in the plane. Prerequisite: MA 620 or equivalent.

MA 646 Theory of Partial Differential Equations 2½:0:3

MA 649-650 Topics in Ordinary and Partial Differential Equations each 2½:0:3
Content of course varies. In spring of year prior to one in which course is offered, detailed description posted and mailed to all graduate mathematics students. Prerequisite: MA 620 or equivalent.

MA 658 Calculus of Variations 2½:0:3
Extension of elementary theory of maxima and minima. Euler equations, conditions of Weierstrass, Legendre, and Jacobi, Mayer fields, Hamilton-Jacobi equations, transversality, conjugate and focal points. Applications to geodesics, minimal surfaces, isoperimetric problems, Hamilton's principle, Fermat's principle, brachistochrones. Prerequisite: MA 202 or MA 212 or MA 620.

MA 661-662 Special Functions of Mathematical Physics I, II each 2½:0:3
Gamma functions, orthogonal polynomials, hypergeometric functions, special cases such as Legendre functions, confluent hypergeometric functions—in particular, Whittaker and Bessel functions. Hill's equations with emphasis on Mathieu equation. Stress on development as functions of complex variable and as asymptotic series. MA 661 prerequisite: MA 630 or MA 622. MA 662 prerequisite: MA 651.

MA 681-682 Functional Analysis I, II each 2½:0:3
Hilbert spaces, Banach spaces, Banach algebras, linear operations, spectral theory, perturbation theory, completely continuous operators, Gelfand theory. Application of these in classical analysis. Prerequisite: MA 703 or equivalent.

MA 683-684 Special Topics in Functional Analysis each 2½:0:3
Content of course varies. In spring of year prior to one in which course is offered, detailed description posted and mailed to all graduate mathematics students. MA 683 prerequisite: MA 692. MA 684 prerequisite: MA 683.

ALGEBRA AND NUMBER THEORY

MA 703 Linear Algebra 2½:0:3
Systems of linear equations and matrices, determinants, vector spaces, linear transformations, eigenvalues, eigenvectors, diagonalization, symmetric matrices, introduction to numerical methods of linear algebra. Prerequisites: MA 103 and MA 104 or equivalent.

MA 705 Linear and Modern Algebra I 2½:0:3
Basic algebraic structures, groups, rings, fields, integral domains, ideals, modules. Extensions of fields. Galois theory. Prerequisite: MA 620 or equivalent.

MA 706 Linear and Modern Algebra II 2½:0:3

MA 715-718 Advanced Topics in Algebra each 2½:0:3
Content of course varies. In spring of year prior to one in which course is offered, detailed description posted and mailed to all graduate mathematics students. MA 715 prerequisite: MA 705 and MA 706. MA 716 prerequisite: MA 715.

GEOMETRY AND TOPOLOGY

MA 754 Topological Methods in Analysis 2½:0:3
Aspects of topological methods and applications to existence theorems in analysis. Use of fixed-point theorems and topological degree in study of properties of solutions of ordinary and partial differential equations. No previous courses in topology required. Prerequisite: MA 212 or MA 620.

MA 755-756 Topology I, II each 2½:0:3
Topological spaces, compactness, connectedness, continuity, extension theorems, metrization theorems, Simplices, simplicial topology and applications, fixed-point theorems, graphs and networks, homology and cohomology theory, introduction to Morse theory. MA 755 prerequisite: MA 620 or equivalent. MA 756 prerequisite: MA 755.

MA 775-776 Manifolds—Geometry and Differentiable Topology I, II each 2½:0:3
Elementary theory of manifolds. Tangent space, mappings, submanifolds, fields, fiber bundles, Lie groups, homogeneous
### APPLIED MATHEMATICS

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 801-802</td>
<td>Special Topics in Applied Mathematics I, II</td>
<td>2 1/2:0:3</td>
<td>MA 153, MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 804</td>
<td>Calculus of Finite Differences</td>
<td>2 1/2:0:3</td>
<td>MA 801-802 prerequisite: linear algebra and complex variables.</td>
</tr>
<tr>
<td>MA 806-806</td>
<td>Tensor Analysis I, II</td>
<td>2 1/2:0:3</td>
<td>MA 103 and MA 104</td>
</tr>
<tr>
<td>MA 819-820</td>
<td>Theory of Approximation</td>
<td>2 1/2:0:3</td>
<td>MA 103 and MA 104</td>
</tr>
<tr>
<td>MA 821-822</td>
<td>Numerical and Approximate Analysis I, II</td>
<td>2 1/2:0:3</td>
<td>MA 103 and MA 104</td>
</tr>
<tr>
<td>MA 823</td>
<td>Special Topics in Numerical Analysis</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 825</td>
<td>Numerical Linear Algebra</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 833</td>
<td>Partial Differential Equations of Mathematical Physics</td>
<td>3 1/2:0:4</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 835</td>
<td>Potential Theory</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
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<tr>
<td>MA 836</td>
<td>Applied Complex Variables</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 837</td>
<td>Applied Matrix Theory</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 838</td>
<td>Linear Algebra and Differential Equations</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 839</td>
<td>Introduction to Functional Analysis</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
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<tr>
<td>MA 841-842</td>
<td>Integral Equations I, II</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
<tr>
<td>MA 844</td>
<td>Optimal Control Theory</td>
<td>2 1/2:0:3</td>
<td>MA 801 prerequisite: MA 801</td>
</tr>
</tbody>
</table>
Hamilton-Jacobi theory as applied to synthesis problem. Optimization problems with state variable constraints. Prerequisites: EL 723.

Also listed under EL 823

MA 846 Fourier and La Place Transforms 2½:0:3

Application of transform methods of partial differential equations of mathematical physics. Includes introduction to Wiener-Hopf technique. Prerequisites: MA 831 or MA 620 or MA 530.


PROBABILITY, STATISTICS, OPERATIONS RESEARCH

MA 812 Theory of Games 2½:0:3


MA 813 Linear Programming 2½:0:3


Also listed under IE 631

MA 814 Integer Programming 2½:0:3


Also listed under IE 633

MA 815 Theory of Queues 2½:0:3

Steady-state solutions for single and multiple channels, various arrival and service distributions, queue disciplines. Transient solutions. Emphasis on theory with solution techniques given for specific classes of queues. Prerequisite: MA 223.

MA 815-817 Graph Theory I, II each 2½:0:3

Graphs and subgraphs, connectivity, trees and girth, planarity, embeddings, n-connectivity and edge-connectivity, Hamilton graphs, matchings, factorization and covering, graphs and groups, graph isomorphism and reconstruction, colorings, map colorings, Ramsey and extremal graph theory, enumeration, connectedness in digraphs. Eulerian and Hamilton digraphs, tournaments, networks. MA 816 prerequisites: MA 103, and MA 104; MA 817 prerequisites: MA 815.

MA 818 Nonlinear Programming 2½:0:3


Also listed under IE 632


MA 851 Probability Theory 3½:0:4½

Second course in probability, at graduate level. Probability of events, distribution of random variables, joint distribution, characteristic functions, proofs of central limit theorem and laws of large numbers. Prerequisite: MA 103 and MA 104, MA 223 or equivalent.

MA 852 Stochastic Processes 3½:0:4½


The following sequence, MA 851-855, covers material of MA 851-852 in three courses of three units each.

MA 853 Probability I 2½:0:3

Probability for events, distribution of random variables, joint distribution, transformations. Prerequisites: MA 103 and MA 104, MA 223 or equivalent.

MA 854 Probability II 2½:0:3


MA 855 Stochastic Processes 2½:0:3

Normal and stationary processes, Wiener processes, Poisson and renewal processes, Markov processes. Prerequisites: MA 854 or equivalent.

MA 861-862 Principles of Statistical Inference I, II each 2½:0:3


MA 863-864 Multivariate Analysis I, II each 2½:0:3


MA 865-866 Regression and Analysis of Variance I, II each 2½:0:3


MA 867 Nonparametric Methods in Statistics 2½:0:3

Statistical methods not bound by assumption of known parametric form distribution of observations. Applications to engineering and scientific research in which observations are not ordered on numerical scale. Order statistics, tolerance regions, permutation tests, goodness of fit tests, ranking distributions, large-sample properties of tests. Prerequisite: MA 224 or MA 552.

MA 868 Sequential Statistical Methods 2½:0:3

Fixed sample size vs. sequential statistical procedures. Wald's sequential probability ratio test, OC and ASN functions, optimality properties, approximation, generalizations. Sequential estimation, optimal stopping. Sequential design of experiments. Application to sampling inspection, inventory and control problems. Prerequisite: MA 224 or MA 562/SA 603.
MA 669-870 Advanced Statistical Inference I, II each 2½-0:3
First semester general decision problem, optimal decision rules, estimation based on Bayes, minimax, admissible, maximum, likelihood, sequential rules, density and distribution estimation. Second semester, hypothesis testing, including uniformly most powerful tests, least favorable distributions unbiasedness, rank tests, invariance, sequential tests. Prerequisite: MA 869 or equivalent.

MA 871-872 Advanced Probability I, II each 2½-0:3

MA 873-874 Theory of Stochastic Processes I, II each 2½-0:3

MA 881-882 Statistical Analysis of Time Series I, II each 2½-0:3
Careful study of tractable models for statistical analysis of scalar time series. Models treated: (1) "error plus trend" models and (2) stationary stochastic process models with special emphasis on autoregressive models. Estimation, tests of hypotheses and multiple-decision procedures for these models. Spectral representation and filtering, estimation of spectral density. Prerequisites: MA 153, MA 852 and MA 862.

MA 931-932 Selected Topics in the Teaching of Mathematics I, II each 2½-0:3
Advanced or specialized topics relevant for the teaching of mathematics in grades 7-12.

READING, PROJECT, THESIS, DISSERTATION

MA 955 Applied Science Project Related to Public Administration I, II each 2½-0:3
This program is discussed in the catalog section on the Cooperative Program with the NYU Graduate School of Public Administration.

MA 941-944 Reading in Mathematics I-IV each 2½-0:3
Courses designed primarily for students who have completed two years of full-time graduate study and who wish to do research on specialized area. Reading done under guidance of faculty member and devoted mainly to scholarly papers. Prerequisite: permission of department.

MA 951-952 Topics in Mathematical Biology I, II each 2½-0:3
Topic varies at discretion of instructor. Mathematical genetics, mathematics of circulatory system, biological application of stochastic processes, applications of wave equation in biology. Course designed so that visiting professor may lecture on special area of interest.

MA 955-956 Selected Topics in Advanced Mathematics I, II each 3½-0:4½
Review of current mathematical research, designed for mature students. May be given by visiting professor. Specific topics vary, depending on instructor. Prerequisite: permission of department.

MA 958-959 Selected Topics in Advanced Mathematics I, II each 2½-0:3
Same course description as MA 955-956 except for credit structure. Prerequisite: permission of department.

MA 996 Project each 3 units
Teaching materials of mathematics in grades 7-12, selected and developed in consultation with a faculty member.

MA 997 Thesis for Degree of Master of Science each 3 units
Thesis to present results of independent investigation of suitable problem in abstract or applied mathematics. Study must include adequate investigation of existing literature relating to subject. Regular reports on progress of work and regular conferences with assigned faculty adviser required. Reregistration fee, any part: 3-unit charge. Prerequisite: degree status.

MA 999 Dissertation for Degree of Doctor of Philosophy each 3 units
Results of independent investigation of some problem in mathematics. Must demonstrate ability to do creative work and include original research of caliber deemed worthy of publication in recognized scientific journals. Oral examination on subject of dissertation and related topics required. Minimum of 24 dissertation units required for degree. Reregistration fee, any part: 3-units charge. Prerequisite: degree status and qualifying examination.

ST 995 Project for Degree of Master of Science (Statistics) each 3 units
Results of detailed study from the field of statistics carried out under the supervision of faculty adviser. Prerequisite: degree status. Reregistration fee, any part: 3-unit charge.

ST 997 Thesis for Degree of Master of Science (Statistics) each 3 units
Thesis presents results of independent investigation of suitable aspects of statistics. Investigation of existing literature and related work must be included. Topic is selected with the help of a faculty adviser who also supervises the thesis work. Prerequisite: degree status. Reregistration fee, any part: 3-unit charge.

ST 999 Dissertation for Degree of Doctor of Philosophy (Statistics) each 3 units
Results of independent investigation of some area of statistics. Must demonstrate ability to do creative work and include original research of caliber deemed worthy of publication in recognized scientific journals. Oral examination on subject of dissertation and related topics is required. Prerequisite: degree status and qualifying examination. Reregistration fee, any part: 3-units charge.
Students in other departments should note that there are certain undergraduate courses in mathematics that may be accepted for graduate credit in their departments. Such courses are identified by a dagger following the course number (e.g., MA 223t). A list of such courses follows.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 153</td>
<td>Elements of Linear Algebra</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 154</td>
<td>Elements of Abstract Algebra</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 177</td>
<td>Transformation Geometry</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 178</td>
<td>Projective Spaces</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 194</td>
<td>History of Mathematics</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 223</td>
<td>Introduction to Probability</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 224</td>
<td>Introduction to Mathematical Statistics</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 231-232</td>
<td>Statistical Methods I, II</td>
<td>3 cr. ea.</td>
</tr>
<tr>
<td>MA 238</td>
<td>Applied Probability</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 531-532</td>
<td>Applied Mathematics in Engineering and Science</td>
<td>3 cr. ea.</td>
</tr>
<tr>
<td>MA 541-542</td>
<td>Fundamental of Discrete Mathematics I, II</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 558-559</td>
<td>Topics in Geometric Optimization I, II</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 581</td>
<td>Elements of Probability</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 552</td>
<td>Elements of Mathematical Statistics</td>
<td>3 cr.</td>
</tr>
<tr>
<td>MA 575</td>
<td>Differential Geometry</td>
<td>3 cr.</td>
</tr>
</tbody>
</table>

**FACULTY**

**Harry Hochstadt,** Professor and Head of Mathematics  
B.Ch.E., Cooper Union; M.S., Ph.D., New York University  
*Differential equations, spectral theory, functional analysis*

**Andrew Terzuoli,** Professor of Mathematics and Administrative Officer  
B.S., Brooklyn College, M.S., New York University  
*Probability, statistics*

**George Bachman,** Professor of Mathematics  
B.E.E., M.S., Ph.D., New York University  
*Fields and valuations, Banach algebras, topological measure theory*

**Emeric Deutsch,** Professor of Mathematics  
B.S., Pedagogical Institute of Timisoara (Romania);  
M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Matrix theory, functional analysis*

**Heinrich Guggenheimer,** Professor of Mathematics  
Dipl., Dr.Sc., Swiss Federal Institute of Technology,  
Zurich (Switzerland)  
*Differential equations, geometry-convexity*

**Leon H. Herbach,** Professor of Mathematics and Statistics  
A.B., Brooklyn College; M.A., Ph.D., Columbia University  
*Reliability, stochastic models of physical systems, Monte Carlo methods*

**Ronald Hirshon,** Professor of Mathematics  
B.S., M.S., Brooklyn College; Ph.D., Adelphi University  
*Group theory*

**Clifford Marshall,** Professor of Mathematics  
B.A., Hofstra University; M.A., Syracuse University;  
M.S., Polytechnic Institute of Brooklyn; Ph.D., Columbia University  
*Graph theory, conflict analysis, applied probability*

**Stanley Preiser,** Professor of Mathematics and Computer Science  
B.S., CCNY, M.S., Ph.D., New York University  
*Numerical analysis, applied mathematics, algorithms, system performance evaluation*

**George Welli,** Professor of Mathematics  
Lic. Math., Dr.Sc., University of Paris (France);  
Ph.D., University of Southern California  
*Complex analysis, global analysis, partial differential equations*

**William R. Allen,** Associate Professor of Mathematics  
B.Ed., Chicago Teachers College; M.S., Northwestern University  
*Data analysis, experimental design*

**Kathryn Kuiken,** Associate Professor of Mathematics  
B.A., M.A., Montclair State College; M.S., New York University; Ph.D., Polytechnic Institute of New York  
*Group theory*

**Burton Lieberman,** Associate Professor of Mathematics  
B.A., Harvard University; M.S., Ph.D., New York University  
*Differential equations, stochastic processes*

**Erwin Lutwak,** Associate Professor of Mathematics  
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Convexity*

**Edward Y. Miller,** Associate Professor of Mathematics  
B.A., University of Pennsylvania, M.A., Ph.D., Harvard University  
*Topology*

**Paul F. Pickel,** Associate Professor of Mathematics  
B.S., Ph.D., Rice University  
*Infinite groups, rings theory, algebraic topology*

**Joel Rogers,** Associate Professor of Mathematics  
B.S., Ph.D., Massachusetts Institute of Technology  
*Partial differential equations, fluid mechanics, numerical methods*

**Lesley Sibner,** Associate Professor of Mathematics  
B.A., CCNY; M.S., Ph.D., New York University  
*Partial differential equations, global analysis*

**Hermann Waldinger,** Associate Professor of Mathematics  
B.A., Pomona College; M.Sc., Brown University; Ph.D., Columbia University  
*Combinatorial group theory*

**Erich Zauderer,** Associate Professor of Mathematics  
B.A., Yeshiva College; M.S., Ph.D., New York University  
*Nonlinear wave propagation, partial differential equations, diffraction problems*
ADJUNCT FACULTY

Barbara Cain, Lecturer
B.S., Syracuse University; M.S., New York University

James Camacho, Jr., Lecturer
M.S., Polytechnic Institute of New York

Daniel Drance, Lecturer
M.S., State University of New York, Stony Brook

Barry Glotzer, Lecturer
B.S., M.S., Brooklyn College

Wallace Goldberg, Lecturer
B.A., Yeshiva University; M.S., New York University; Ph.D., Polytechnic Institute of New York

Carlos Huerta, Lecturer
M.S., Polytechnic Institute of New York

Alfred Kalfus, Lecturer
M.S., Adelphi University

Dasarat Misir, Lecturer
B.S., M.S., City University of New York

Rose Slomowitz, Lecturer
B.S., M.A., Brooklyn College

Daniel Steinitz, Lecturer
B.Sc., Hebrew University, Jerusalem, Israel; M.Sc., New York University

Martin Weinless, Lecturer
B.S., City University of New York

EMERITUS FACULTY

Aaron Fialkow, Professor Emeritus
B.S., M.S., CCNY; Ph.D., Columbia University
Differential geometry, network theory

Ronald M. Foster, Professor Emeritus
B.A., Harvard; D.Sc. (Hon.), Fairleigh Dickinson University; D.Sc. (Hon.)
Polytechnic Institute of New York
Network theory, graph theory
At the undergraduate level the Department of Mechanical and Aerospace Engineering offers two distinct programs, each leading to the degree of bachelor of science: one in aerospace engineering and one in mechanical engineering. Each of these two degrees is offered at both the Brooklyn and Long Island campuses. At the graduate level, four separate curricula are offered: the first in applied mechanics, the second in aeronautics and astronautics, and the third and fourth in mechanical engineering. The latter two are distinguished by options in (1) mechanical analysis and design and (2) the thermal/fluids/energy field, respectively. In each of these four curricula, graduate degrees are offered at the master of science, engineer, and doctor of philosophy levels.

UNDERGRADUATE PROGRAMS

Aerospace Engineering — The undergraduate aerospace program not only affords students an understanding of basic scientific principles but trains them in the application of such principles to the problems of their profession. The sophistication of aerospace systems is such that students must necessarily master some of the more powerful analytic techniques in order to evolve an efficient design. The training is broad, so that graduating students can apply their knowledge to such diverse problem areas as air and noise pollution, land and sea vehicles, waste disposal, oceanographics and biomechanics.

During the first two years of study, the foundation for future professional subjects is established by courses in each of the basic sciences; physics, chemistry, and mathematics. Although the student begins training in a number of engineering science areas such as computers, mechanics, material science and strength of materials, the emphasis is primarily on principles and concepts in fundamental and basic sciences.

Mechanical Engineering — For undergraduates in mechanical engineering, a strong program in mathematics, physics, chemistry, and computer usage provides the base for subsequent courses in engineering sciences such as solid and fluid mechanics, thermodynamics, and dynamic system analysis. The curriculum then develops engineering analysis and concludes with engineering design and energy conversion. Project work in the senior year integrates the diverse disciplines in mechanical engineering.

A valuable feature of the program is the availability of technical electives in each of the last four semesters. In consultation with a faculty adviser, the student may construct a minor in one of many technical areas outside traditional mechanical engineering. Alternatively, the student may pursue areas of mechanical engineering in greater depth. In either case, the mechanical engineering program offers the basic and engineering sciences as the foundation for subsequent graduate studies and outstanding career opportunities.

The undergraduate program leads to the degree of bachelor of science in mechanical engineering and is accredited by the Accreditation Board for Engineering and Technology.
### Typical Course of Study for the Bachelor of Science Degree in Aerospace Engineering

#### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>MA 101 Calculus I</td>
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<td>PH 101 Introductory Physics I</td>
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<td>CS 100A Intro. to Programming</td>
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<tr>
<td>HU 101 College Composition</td>
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<td>SS 104 Contemp. World Hist.</td>
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<td>PE 101 Phys. Ed.</td>
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<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
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<td>MA 102 Calculus II</td>
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<tr>
<td>AM 111 Mechanics I</td>
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<td>HU 200 Intro. to Lit</td>
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<td><strong>Total</strong></td>
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#### Sophomore Year

| MA 103 Calculus III | 3 0 3 |
| PH 103 Introductory Physics III | 2 1 1 |
| CM 101 General Chemistry I | 2 1 3 |
| CM 111 General Chemistry Lab I | 1 1 2 |
| AM 101 Graphics | 1 2 2 |
| AM 112 Mechanics II | 3 0 3 |
| AM 201 Thermodynamics I | 3 0 3 |
| AM 211 Fluids I | 3 0 3 |
| AM 271 Fund. Stress Analysis I | 3 0 3 |
| AM 311 Mechanics of Flight I | 3 0 3 |
| **Total** | **17** |

#### Junior Year

| MA 333 Partial Diff. Equations | 3 0 3 |
| AM 251 Dynamics | 3 0 3 |
| AM 252 Dynamic System Response | 3 0 3 |
| AM 273 Fund. Stress Analysis II | 2 1 1 |
| AM 341 Aircraft Design I | 2 3 3 |
| **Total** | **18** |

#### Senior Year

| AM 233 Fluids III | 3 0 3 |
| AM 261 Vibrations | 3 0 3 |
| AM 281 Advanced Stress Analysis I | 2 1 1 |
| AM 312 Mechanics of Flight II | 3 0 3 |
| AM 343 Aircraft Design II | 3 0 3 |
| **Total** | **18** |

| AM 241 Propulsion | 3 0 3 |
| AM 344 Spacecraft Design | 2 3 3 |
| AM 350 Fluids Laboratory | 3 0 3 |
| **Total** | **16** |

**Total credits required for graduation:** 136

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1. Free electives are subject to a departmental adviser's approval.
2. ROTC students may substitute four (4) military science courses of zero (0) credits for PE 101-104. Additionally, up to six (6) credits from the following four (4): 2-credit courses; MS 301, 303, 401, or 403, may be used to substitute for the free elective(s) which exist in the aerospace and mechanical engineering programs.
3. Approved technical electives are listed as follows: AM 234, AM 262 and 268. The choice of any of the above electives or possible other technical electives must be accompanied by a departmental adviser's approval.

In addition, the student is strongly urged to select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religion in the Department of Humanities or political science, economics, history, anthropology or psychology in the Department of Social Sciences) and elect two or three courses in this concentration, in consultation with the departmental adviser. A modern language may be chosen as a suitable concentration but a student without prior knowledge of the language must plan to devote at least 12 credit hours to the subject. Also, HU 110 must be taken during the sophomore year. Any student whose last name falls in the range A-L will register for HU 110 in the Fall semester. Any student whose last name falls in the range M-Z will register for HU 110 in the Spring.

For the remaining credits in the humanities/social science requirement, the student should select courses in areas other than that of the concentration. Additional courses in the humanities and social sciences may be taken as free electives, the total number of humanities and social science credits required being at least twenty-four.
### Freshman Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
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<td>MA 101 Calculus I</td>
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<td>PH 101 Introductory Physics I</td>
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**Second Semester**

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<td>CM 101 General Chemistry I</td>
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<td>CM 111 General Chemistry Lab I</td>
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**Total credits required for graduation: 136**

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### Sophomore Year

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<td>PH 103 Introductory Physics III</td>
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<td>CM 103 General Chemistry I</td>
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<td>AM 111 Mechanics I</td>
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<td>Hum/Soc. Sci. or HU 110*</td>
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**Second Semester**

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<td>MT 102 Structure of Metals</td>
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<td>AM 112 Mechanics II</td>
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<td>AM 202 Fluids II</td>
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<td>AM 252 Dynamic System Response</td>
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<td>AM 302 Anal./Design of Mach. Elem</td>
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<td>AM 331 Comp. Mech. in Design</td>
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**Total credits required for graduation: 136**

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### Junior Year

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<td>AM 201 Thermodynamics I</td>
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<td>AM 231 Fluids I</td>
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<td>AM 301 Synth. of Mech. Systs</td>
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<td>AM 351 ME Laboratory I</td>
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**Second Semester**

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<td>AM 302 Anal./Design of Mach. Elem</td>
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<td>AM 331 Comp. Mech. in Design</td>
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**Total credits required for graduation: 136**

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### Senior Year

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<td>AM 261 Vibrations</td>
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<td>AM 271 Fund. Stress Analysis I</td>
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<td>AM 352 ME Laboratory II</td>
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<td>Project Proposal</td>
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**Second Semester**

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<th>No.</th>
<th>Subject</th>
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<td></td>
<td>AM 204 Energy Transfer Design</td>
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<td>AM 272 Stress Anal. of Mech. Comp.</td>
<td>3</td>
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<td>AM 321 Instrumentation &amp; Control</td>
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<td>AM 353 ME Laboratory II</td>
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<td>ME Project</td>
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</tbody>
</table>

**Total credits required for graduation: 136**

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*Technical Minors — A valuable feature of the mechanical engineering program is availability of technical electives in each of the last four semesters. In consultation with a faculty advisor, the student may construct a minor in numerous and diverse technical areas outside traditional mechanical engineering.*
EVENING PROGRAM —
Mechanical Engineering

The degree requirements for part-time evening students in the mechanical engineering program are in all respects identical to those for full-time students. The evening program is structured so that a student may complete all requirements in eight years without summer work.

Course of Study for the Evening Program in Mechanical Engineering

<table>
<thead>
<tr>
<th>First Year</th>
<th>Hours/Week</th>
<th>Second Year</th>
<th>Hours/Week</th>
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<td>First Semester</td>
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<td>Second Semester</td>
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<td>MA 102 Calculus II</td>
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<td>PH 101 Introductory Physics I</td>
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<td>SS 104 Contemp. World History</td>
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<td>Second Year</td>
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<td>No. Subject</td>
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<tr>
<td>HU 200 Intro. to Literature</td>
<td>3 0 3</td>
<td>AM 101 Graphics (83-84, 85-86)</td>
<td>1 3 2</td>
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<tr>
<td>MA 103 Calculus III</td>
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<td>CS 100 Intro. to Programming</td>
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<td>PH 102 Introductory Physics II</td>
<td>3½ 1½ 4</td>
<td>MA 104 Applied Diff. Equations</td>
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<td>Third Year</td>
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<td>2½ 0 2½</td>
<td>AM 101 Graphics (83-84, 85-86)</td>
<td>1 3 2</td>
</tr>
<tr>
<td>CM 111 General Chemistry Lab. I</td>
<td>0 1½ ½</td>
<td>CS 100 Intro. to Programming</td>
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<td>3 0 3</td>
<td>CM 102 General Chemistry II</td>
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<td>Fourth Year</td>
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<td>MA 333 Partial Diff. Equations</td>
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<td>AM 301 Synth. of Mech. Sys.</td>
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<td>AM 321 Instrumentation &amp; Control</td>
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<td>8</td>
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</tr>
<tr>
<td>Total credits required for graduation: 136</td>
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</tbody>
</table>

*Fifth and sixth years are interchangeable.
†Seventh and eighth years are interchangeable.
GRADUATE PROGRAMS

Programs of study are offered leading to the degrees of master of science, engineer, and doctor of philosophy in mechanical engineering, in aeronautics and astronautics, and in applied mechanics. In mechanical engineering the student may specialize in either (1) the mechanical analysis and design option or in (2) the thermal/fluids/energy option. A bachelor's degree in mechanical, aerospace, civil or chemical engineering is generally required. Applicants with degrees in other fields may be admitted with deficiencies. Mathematics or physics majors who have completed an undergraduate course in strength of materials may be admitted to the applied mechanics program without deficiencies.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

Core Courses:
A. For mechanical engineering (mechanical analysis and design option) and for applied mechanics

<table>
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<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>AM 601-02</td>
<td>6</td>
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<tr>
<td>AM 603-04</td>
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<tr>
<td>AM 651-52</td>
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<td>AM 653-54</td>
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<tr>
<td>AM 971-72</td>
<td>0</td>
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</tbody>
</table>

Students who have not achieved the level of mathematical proficiency required by MA 333 are required to complete MA 531-32.

B. For mechanical engineering (thermal/fluids/energy option) and aeronautics and astronautics

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>AM 701</td>
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<tr>
<td>AM 710</td>
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<tr>
<td>AM 740</td>
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<tr>
<td>AM 971-72</td>
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</tbody>
</table>

Students who have not achieved the level of mathematical proficiency required by MA 333 are required to complete MA 531-32.

Programs

A1 — Mechanical Engineering (Mechanical Analysis and Design Option)

Core Courses (A) 12

Select 6 additional units from

<table>
<thead>
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<th>Course</th>
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<tbody>
<tr>
<td>AM 601-02</td>
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<td>AM 603-04</td>
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<tr>
<td>AM 613-14</td>
<td>6</td>
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<tr>
<td>AM 651-52</td>
<td>12</td>
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</tbody>
</table>

B1 — Mechanical Engineering (Thermal/Fluids/Energy Option)

Core Courses (B) 9

Select 12 additional units from

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tr>
<td>AM 702</td>
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<td>AM 803</td>
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<tr>
<td>AM 610</td>
<td>15</td>
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</tbody>
</table>

In each of the above master's degree programs a student may pursue a project (up to six units counted toward the degree) or a thesis (up to twelve units counted toward the degree) under the guidance of a faculty sponsor or may elect to complete the program solely with courses. All elective courses must be approved by a graduate adviser and should be consistent with a definable objective associated with the master's program.

In all cases, at least 24 units of work must be completed by the student in departmental courses (including thesis or project) at Polytechnic.

The department limits to nine the total of transfer, readings (guided studies), and validation credits that can be offered for the master's degree. The certification of validation credits is administered by the departmental graduate advisers.

To obtain any graduate degree or certificate, student must have a 3.0 grade point average or better in all graduate courses and a B or better average in all guided studies (readings, project, thesis, dissertation)

Either the core courses or the electives must include AM 651-52, Advanced Dynamics I & II.

197
of the degree requirements. All courses submitted for
the degree must have been completed within the four-
year period prior to the awarding of the degree.

REQUIREMENTS FOR THE
ENGINEER DEGREE

A master's degree in mechanical, aerospace, civil or
chemical engineering that meets one of the depart-
ment specialization area requirements is generally re-
quired. Applicants with master's degrees not meeting
these requirements may be conditionally admitted
with deficiencies as evaluated by a departmental
graduate adviser. Each candidate must complete a
program of study of at least 36 units beyond the
master's degree as approved by an appropriate de-
partmental graduate adviser. This program of study
will normally include at least 24 units of work within the
department; part of this work will include a project of 6
but not more than 12 units. Course work may be
substituted for the project if the applicant's
background includes satisfactory evidence of
equivalent experience as evaluated by the guidance
committee. In addition, satisfactory attendance in AM
971-72 (Seminar in Mechanical and Aerospace
Engineering) is required for two semesters.

To obtain any graduate degree or certificate, student must
have a 3.0 grade point average or better in all graduate
courses and a B or better average in all guided studies

REQUIREMENTS FOR THE
DOCTOR OF PHILOSOPHY DEGREE

A master's degree in mechanical, aerospace, civil or
chemical engineering that meets one of the depart-
ment's area requirements is generally required. Ap-
plicants with degrees not meeting these requirements
may be admitted with credit for previous work as
evaluated by a departmental graduate adviser.

Each candidate for the Ph. D. must complete a
minimum of 36 units of approved courses beyond the
master's degree. In addition, registration for a
minimum of 24 units of dissertation research is re-
quired at the rate of a minimum of three units per term,
continuously, until the dissertation is completed and
accepted. Satisfactory attendance in AM 971-72
(Seminar in Mechanical and Aerospace Engineering) is
required each semester (normally, two semesters for the
M.S. and four additional semesters for the Ph.D.).
All of the above requirements must be met within a
seven-year period prior to awarding the degree.

UNDERGRADUATE COURSES

AM 101 Graphics 1:3:2
Sketching and instrument drawings. Projection theory, multi-
view isometric, oblique, A.H.S.I. standards. Dimensioning, sec-
tions, auxiliary, fasteners, working and assembly drawings.
Descriptive geometry: points, lines, planes. Graphical
mathematics: vectors, calculus. Project: simple concepts relat-
ing to student's major

AM 102 Computer-Aided Drafting 1:3:2
Review of current equipment in the Computer Graphics
Laboratory. Introduction to state-of-the-art developments in
computer-aided drafting techniques. The user-computer in-
terface in operating computer-aided drafting packages. Visual
representation of projection schemes, dimensioning
techniques, sections, and assembly drawings on various dis-
play devices.

AM 111 Mechanics I 3:0:3
Three dimensional vector treatment of the static equilibrium of
particles and rigid bodies. Equivalent force and couple sys-
tems. Distributed force systems. Static analysis of trusses,
frames and machines. Friction, impending motion. Method of
virtual work. Potential energy and stability of equilibrium. Pre-
quisite: PH 101 and MA 102.

AM 112 Mechanics II 3:0:3
Three-dimensional vector treatment of the kinematics and kine-
tics of particles and rigid bodies using various coordinate sys-
tems. Newton's laws, work, energy, impulse, momentum, conser-
vative force fields, impact, Rotation and plane motion of
rigid bodies. Prerequisite: AM 111.

AM 115 Engineering Mechanics 4:0:4
Equivalent to AM 116 and AM 117. Prerequisites: MA 102 and
PH 101.

AM 116 Engineering Mechanics I 2:0:2
Three dimensional vector treatment of the static equilibrium of
particles and rigid bodies. Equivalent force and couple sys-
tems. Static analysis of trusses, frames, and machines. Fric-
tion, impending motion. Prerequisite: PH 101. Co/Prerequisite:
MA 102.

AM 117 Engineering Mechanics II 2:0:2
Three-dimensional vector treatment of the kinematics and kine-
tics of particles using various coordinate systems. Newton's
laws, work, energy, impulse, momentum, conservative force
fields, impact. Prerequisite: AM 116.

AM 118 Engineering Mechanics III 2:0:2
Analysis of virtual work. External energy and stability of equi-
librium. Distributed force systems. Kinematics and kinetics of
rigid bodies. Rotation and plane motion of rigid bodies. AM
116, AM 117 and AM 118 equivalent to AM 111 and AM 112.
Prerequisite: AM 117.

AM 121 Mechanics of Materials 3:0:3
Basic principles of stresses and strains of members subjected to
direct force, torsion and bending. Definitions of beams.
Statically determinate and indeterminate problems. Column
stability. Prerequisite: AM 111 or AM 115 or AM 116.
Also listed under CE 202

AM 201 Thermodynamics I 3:0:3
Properties of pure substances, concepts of work and heat.
closed and open systems. The fundamental laws of ther-
momodynamics, entropy and entropy production. Carnot and
Clairaut statements; heat engines, refrigerators, heat pum-
es. efficiency coefficients of performance. Prerequisites: MA 104
and PH 102.

AM 202 Thermodynamics II 3:0:3
Continuation of AM 201. Irreversibility and availability. Power
and refrigeration cycles. Maxwell's equations and other thermo-
dynamics relations. Properties of mixtures, air-condition-
ing. Energy and equilibrium aspects of chemical reactions;
heme temperatures. Introduction to phase and chemical
equilibrium. Prerequisite: AM 201.
AM 203 Heat Transfer 3:0:3

AM 204 Design of Energy Transfer and Conversion Systems 3:0:3
Principles of thermodynamics, fluid dynamics and heat transfer applied to design of heat exchangers. Application of first and second laws of thermodynamics to design and evaluation of energy conversion cycles. Detailed heat exchangers or energy system design required of student. Prerequisite: AM 202 and AM 203.

AM 211 Statistical Thermodynamics* 3:0:3
Review of elementary probability theorems, statistical mechanics of noninteracting particles. Development of engineering thermodynamic expressions. Applications to engineering problems including deduction of thermodynamic properties for elementary gases and solids, thermal radiation from solids. Calculation of transport properties. Senior elective. Prerequisite: AM 201.

AM 212 Air Conditioning and Refrigeration* 3:0:3
Application of thermodynamics and other sciences needed for rational approach to solution of engineering problems in air conditioning and refrigeration. Senior elective. Prerequisite: AM 201.

AM 213 Transport Processes* 3:0:3
Extension of principles developed in AM 201, AM 203, and AM 231. Detailed study of energy and momentum, heat and mass transfer processes. Unified treatment using transport phenomena methods. Senior elective. Prerequisite: AM 212.

AM 231 Fluids I 3:0:3

AM 232 Fluids II 3:0:3

AM 233 Fluids III 3:0:3

AM 234 Fluids IV 3:0:3

AM 241 Propulsion 3:0:3
Basic principles of operation, performance, design methods for high-speed vehicle propulsion systems. Airbreathing engines, turbojet, turboprop, turboshaft and ramjet. Liquid and solid propellant chemical rockets. Elements of nuclear and electrical rocket propulsion systems. Prerequisite: AM 232.

AM 242 Rocket Propulsion* 3:0:3
Introduction to development and design of rocket engines. Basic principles of mechanics, thermodynamics, aerodynamics and combustion literature. Propellants, rocket engine elements (solid and liquid), heat transfer, cooling of engines, rocket testing and problems associated with rocket design and development. Senior elective. Prerequisite: senior status.

AM 243 Turbomachinery* 3:0:3
Thermodynamics, fluid mechanic principles and elements of turbomachinery (fans, pumps, compressors, turbin). Senior elective. Prerequisite: senior status.

AM 251 Dynamics 3:0:3
Motion of a particle, systems of particles, rigid bodies. Momentum and energy principles and applications. Impulsive forces and moments. Projectile with air resistance. Gyroscopic theory. Prerequisites: AM 112 and MA 104.

AM 252 Dynamic Systems Response 3:0:3
Basic dynamic behavior of mechanical, fluid, thermal and electrical elements for simple element behavior to complex systems. Modeling and formulation of system equations. Analogies stressed and computer simulations introduced. Generalized first- and second-order dynamic systems subject to various excitation. Prerequisite: AM 112 or AM 115 or AM 117.

AM 251 Vibrations 3:0:3

AM 252 Noise and Acoustics* 3:0:3

AM 253 Advanced Vibration* 3:0:3

AM 271 Fundamentals of Stress Analysis 1 3:0:3

AM 272 Stress Analysis of Mechanical Components 3:0:3
AM 273 Fundamentals of Stress Analysis II 2:3:1
Torsion of thin-walled open and closed section beams. Membrane and hydrodynamic analogies, Bredt's formula, multiaxial cross sections. Strain energy, Castigliano's theorems. Classically indeterminate beams, frames, rings. Laboratory: experimental stress analysis, strain gages, brittle coating, photelasticity, analogies. Prerequisite: AM 271.

AM 281 Advanced Stress Analysis I 2:3:1
Elastic and inelastic buckling of columns, frames, plates, shells, effective width, shear-stringer combinations; torsional instability, energy methods for approximate solutions. Continuation of experimental stress analysis methods developed in AM 273. Prerequisite: AM 273.

AM 282 Advanced Stress Analysis II 3:0:3

AM 301 Synthesis of Mechanical Systems 3:0:3
Kinematic analysis of linkages, velocity and acceleration images. Instantaneous centers. Design of cams, gears, gear trains. Geometric and algebraic methods of synthesis for path and function generation. Prerequisite: AM 112 or AM 115 or AM 117.

AM 302 Analysis and Design of Machine Elements 3:0:3
Application of basic principles to in-depth analysis and design of selected machine elements, typically, brakes, clutches, spindles, screws, shafting, belt and gear systems. Fundamentals of friction, wear, boundary, hydromechanical lubrication. Engineering principles from several disciplines applied to individual problems. Prerequisite: AM 121 and MA 333.

AM 311 Mechanics of Flight I 3:0:3
Principles of powered flight, development of equations of motion, performance of subsonic and supersonic airplanes, discussion of characteristics of various power plants. Properties of fluids, dimensional analysis, one-dimensional flows, subsonic airflow and wing and propeller theory and practice. Prerequisites: AM 112 or AM 115 or AM 117 and AM 341.

AM 312 Mechanics of Flight II 3:0:3

AM 321 Instrumentation and Control 3:0:3
Operation of mechanical and electromechanical instrument components. Active and passive transducer elements for steady and non-steady temperature, pressure, displacement, acceleration, measurement, instruments and feedback control systems. Introduction to statistical analysis of data. Design of measurement or control systems. Prerequisite: AM 251 or AM 252.

AM 322 Machine Control Systems* 3:0:3
Application of feedback principles to machine systems. Use of classical and transform methods for transient and steady-state solutions. Prerequisite: AM 321.

AM 331 Devices and Computational Methods in Computer Aided Design 2:3:3
Introduction to computing hardware peripherals used for computer aided design, digitizing tablets, storage tube and refresh graphics terminals, plotters, light pens. Laboratory sessions reinforce classroom instruction through use of remote terminals and mainframe computer, micro-computers and graphics peripherals. Students are required to develop elementary graphics software for CAD applications. Prerequisites: CS 100, MA 104, and AM 101.

AM 332 Computer Graphics In Computer Aided Design 2:3:3
Computational methods for geometric representation, of complex geometries including curved surfaces. Rotation and perspective considerations. Review and application of representative CAD packages. Interfacing graphics and analysis software for design interaction. Laboratory work includes use of packaged programs and a student project involving geometric data development and use in conjunction with analysis tools for design. Prerequisite: AM 331.

AM 337 Introduction to Robotics 3:0:3
A survey of robotics and the relevant fields related to robot design and operation. Introduction to the kinematic problems peculiar to robotic construction, a survey of the control considerations, power sources, and the need for sensor equipment and intelligence. Examination of the specifications useful for evaluating robot performance and some considerations of the economics of robotized operations. Prerequisites: AM 301 and AM 302.

AM 341 Introduction to Aerodesign 2:3:3
Consideration of the nature of design synthesis and analysis as it pertains to aerospace. Qualitative and quantitative aspects of feasibility, design methodology, modeling, use of computers, iteration and optimization in terms of design project. Co prerequisities: AM 121.

AM 342 Aircraft Design I 2:3:3

AM 343 Aircraft Design II 2:3:3
Structural design of airplane based on specification and aerodynamic requirements. Discussion of construction materials, forming, fasteners, fittings, structural arrangement of landing gear, fuselage, stress analysis. Prerequisite: AM 342.

AM 344 Spacecraft Design 2:3:3
Design of hypervelocity vehicles. Trajectory and orbit analysis. Problems of re-entry, propulsion system design and staging. Design of a boost vehicle for satellite missions, and a re-entry vehicle for earth return. Prerequisite: AM 343.

AM 350 Fluids Laboratory 0:3:1
Laboratory experiments in the area of inviscid and viscous flows. Prerequisite: AM 233.

AM 351 ME Laboratory I 5:1:1
Instrumentation principles. Experiments related to thermodynamics, system modeling and basic instrumentation. Co prerequisites: AM 201 and AM 112.

AM 352 ME Laboratory II 5:1:1
Experiments related to thermodynamics, fluid properties, systems dynamics, vibrations. Co prerequisite: AM 261.

AM 353 ME Laboratory III 5:1:1
Experiments in heat transfer, fluid flow, stress and strain. Prerequisite: AM 203.
AM 361 ME Project Proposal 2:06:2
Basic design and analysis of engineering project. Formulation of formal plan of execution of design project. Prerequisite: senior status.

AM 362 ME Project 2:06:2
Execution of design project as proposed in AM 361. Prerequisite: AM 361.

AM 363-366 ME Project or Study 1-4 cr. as arranged
Continuation of AM 352 on approval of project adviser. Directed studies or special topics in mechanical engineering. Prerequisite: AM 362.

AM 381-382 Senior Honors Work in Mechanical Engineering I, II 3 cr. credit to be arranged
Independent work undertaken by qualified honors students in mechanical engineering. Course material arranged by faculty steering committee. Prerequisite: senior status.

AM 383-384 Senior Honors Work in Aerospace Engineering I, II 3 cr. credit to be arranged
For aerospace majors; equivalent in scope to AM 381-382

AM 391-392 Guided Studies in Mechanical Engineering I, II 2-12 cr. credit to be arranged
Senior-year sequence for qualified students in mechanical engineering. Course material arranged by committee of faculty members.

AM 393-394 Guided Studies in Aerospace Engineering I, II 2-12 cr. credit to be arranged
For aerospace majors; equivalent in scope to AM 381-382

GRADUATE COURSES

AM 601 Stress Analysis I 2½:0:3

AM 602 Stress Analysis II 2½:0:3

AM 603-604 Elasticity I, II* each 2½:0:3

AM 605 Limit Analysis of Structures* 2½:0:3

AM 606 Applied Plasticity* 2½:0:3

AM 607 Continuum Mechanics* 2½:0:3
Cartesian tensors introduced and employed in analysis of stress and strain. Laws of mechanics and thermodynamics for general material. Introduction of various constitutive relations. Specialization of governing equations to elasticity, thermoelasticity, plasticity, viscoelasticity and creep, and fluid mechanics. Prerequisite: adviser's approval.

AM 611 Advanced Mechanics of Materials* 2½:0:3
Unsymmetrical bending of elastic bars, shear center for members of thin-walled, open cross section, curved beams, beams on elastic foundations, members and bending stresses in shells. Prerequisite: AM 121 or CE 202. Also listed under CE 621

AM 613 Theory of Plates 2½:0:3
Bending theories of plates; analysis of various shapes from equilibrium considerations. Equilibrium equations and boundary conditions derived from energy principles. Exact and approximate solutions. Rayleigh-Ritz, Galerkin. Introduction to large deflection and buckling theories. Application to structures and vehicles. Prerequisite: adviser's approval.

AM 614 Theory of Shells 2½:0:3
Membrane theory of thin shells. Theory of shells with emphasis on circular cylinders. Derivations of buckling theory of circular cylindrical shells. Applications include shell-type roof structures, pressure vessels, underwater structures, vehicles and aerospace structures. Prerequisite: AM 613 or AM adviser's approval.

AM 615 Energy Methods in Structural Analysis* 2½:0:3
Unified treatment of structural analysis using the principles of virtual work, total potential energy, complementary potential, and mixed-energy. Applications to trusses, frames, beams, rings, sandwich structures, and to plane stress and strain problems. Rayleigh-Ritz procedure, Galerkin. Prerequisite: adviser's approval.

AM 616 Theory of Elastic Stability* 2½:0:3
Energy methods employed to investigate buckling loads of structural configurations composed of beams, rings, plates, and shells. Applications to problems of technical interest associated with structures and vehicles. Prerequisite: adviser's approval.

AM 621 Finite Element Analysis of Structural Systems* 2½:0:3
Derivation of element stiffness matrices. Construction of general stiffness matrices in global coordinates. Application to problems in plane stress, plates, and shells under static and dynamic loads. Emphasis on problems involving analysis of systems with many unknowns. Prerequisite: adviser's approval. Also listed under CE 616

AM 623 Computational Methods In Mechanical and Aerospace Engineering I* 2½:0:3
Integrated survey of principal methods in obtaining approximate solutions to boundary value problems that occur in structural analysis. Particular attention to continuum techniques such as Fourier, Ritz, Galerkin, least square and collocation methods. Prerequisite: adviser's approval.

AM 624 Computational Methods In Mechanical and Aerospace Engineering II* 2½:0:3
Continuation of AM 623 with particular emphasis on numerical techniques of analysis, such as finite differences, iteration procedures and Runge-Kutta method. Consideration of recently
developed hybrid methods. Consideration of recently developed hybrid methods. Illustrative examples from contemporary literature in structural analysis. Prerequisite: AM 623.

AM 625 Experimental Stress Analysis* 1:2:0:3
Application of experimental stress analysis techniques to aerospace, civil, and mechanical engineering systems. Mechanical strain gages, electrical strain gages and associated instrumentation, brittle coating, photoelasticity and photostress, moire fringes. Static and dynamic loading, creep and fatigue of structural elements. Prerequisite: adviser’s approval.
Also listed under CE 623

AM 626 Advanced Topics in Experimental Stress Analysis* 1:2:0:3
Course orientation is toward advanced research. Introduction to modern optics followed by analysis of optical image formation. Theory of holography and wave propagation in anisotropic media, advanced topics in three-dimensional photelasticity, analysis of three-dimensional surfaces by means of holography and other optical techniques. Prerequisite: AM 625.

AM 630 Design Methods for Power Plant Structures 2:1:0:3

AM 632 Piping Analysis 2:0:0:3
Also listed under CE 632

AM 634 Pressure Vessel Analysis 2:0:0:3

AM 637 Thermal Stress Analysis I* 2:0:0:3

AM 638 Thermal Stress Analysis II* 2:0:0:3
Energy methods of thermal stress analysis, including modified Castigliano’s theorem, complementary energy, reciprocity theorems, and Rayleigh-Ritz technique. Bending of rings and circular plates. Deformation of cylindrical shells under combined axial and radial temperature distributions. Thermal instability: rings, plates. Prerequisite: AM 637.

AM 651 Advanced Dynamics I 2:0:0:3
Kinematics and dynamics of a particle in space, translating and rotating frames of reference. Systems of particles, plane motion of rigid bodies. Two-body central force problem. Lagrange equations with holonomic and nonholonomic constraints, applications. Prerequisite: adviser’s approval.

AM 652 Advanced Dynamics II 2:0:0:3
General motions of rigid bodies, Euler’s equations, gyroscopic motions and stability, impulsive motions. Linear oscillations of two-degree and n-degree of freedom systems, matrix formulations, applications. Prerequisite: adviser’s approval.

AM 653 Dynamics of Machines 2:0:0:3
Dynamics of systems with one and two degrees of freedom. Energy methods, Rayleigh’s quotient. Generalized coordinates, Lagrange’s equations. Prerequisite: adviser’s approval.

AM 654 Mechanical Vibrations 2:0:0:3

AM 661 Structural Dynamics* 2:0:0:3
Also listed under CE 625

AM 662 Vibrations of Plates and Shells* 2:0:0:3

AM 663 Matrix Methods in Vibrations* 2:0:0:3

AM 664 Dynamic Stability of Structures* 2:0:0:3
Foundations of theory of dynamic stability. Dynamic stability of straight and curved beams, plates, and shells. Linear and nonlinear theories. Prerequisite: adviser’s approval.

AM 671 Analysis of Machines* 2:0:0:3
Classification of mechanisms. Review of planar kinematic analysis. Algebraic and geometric methods for kinematic synthesis. Introduction to spatial linkages. Applications to mechanism design. Prerequisite: adviser’s approval.

AM 672 Kinematic Synthesis of Mechanisms* 2:0:0:3

AM 675 Mechanical Servomechanisms I* 2:0:0:3

AM 676 Mechanical Servomechanisms II* 2:0:0:3
Compensation techniques. Analog computer simulation of control systems. Analysis of nonlinear systems by use of phase plane and describing functions. Typical components and systems. Prerequisite: AM 675.

AM 681 Dynamics of Elastic Solids* 2:0:0:3
rotational inertia and shear in flexural vibrations. Spherical
stress waves. Prerequisite: AM 604

AM 682 Aero- and Hydroelasticity*  2½/0:3
Analysis of problems with nonconservative types forces. Di-
vergence and flutter phenomena, flutter prevention. Applications
to vibrations and instabilities in aerospace, mechanical and
civil engineering. Prerequisite: AM 651.

AM 683 Nonharmonic and Random Vibrations  2½/0:3
Determination of factors controlling dynamic errors in shock
and vibration, analysis of linear and non-linear systems. Ritz
averaging phase-plane and perturbation methods. Response to
periodic and random excitation. Prerequisite: AM 653.

AM 684 Analysis of Nonlinear Systems*  2½/0:3
Introduction to methods of nonlinear analysis, especially to
free and forced nonlinear vibrations. Phase-plane techniques,
perturbation methods, method of harmonic balance and
Krylov-Bogoliubov method. Self-excited oscillations and limit
cycles. Liapunov's second method for stability analysis. Pre-
requisite: adviser's approval.

AM 685 Noise and Acoustics I*  2½/0:3
Survey of mathematical methods, random signals, acoustic
fields, room acoustics, subjective criteria, environmental
criteria. Prerequisite: adviser's approval.

AM 686 Noise and Acoustics II*  2½/0:3
Mechanism of noise generation by helicopters, fan engines,
jets. Noise characteristics of automobiles, trucks, construction
equipment. Estimation of road noise. Problems of subway
Prerequisite: AM 685.

AM 687 Acoustic Radiation from
Submerged Structures*  2½/0:3
Wave equation and elementary solution. Helmholtz integral for-
mulation. Radiation from submerged plates and shells and
associated sound radiators; scattering of sound by rigid and
elastic scatterers, creeping waves. Prerequisite: adviser's ap-
proval.

AM 691-694 Special Topics: ME and Applied
Mechanics* each 2½/0:3
Topics of particular current interest in mechanical engineering
and applied mechanics. Prerequisite: adviser's approval.

AM 701 Thermodynamics I  2½/0:3
Critical study and review of classical thermodynamics. Avail-
ability functions, general thermodynamic relations, equations of
state, general thermodynamics equilibrium criteria. Prequisi-
te: AM advisor's approval.

AM 702 Thermodynamics II*  2½/0:3
Continuation of AM 701. Application of thermodynamic equi-
librium criteria to various problems, including chemical reactions.
Prerequisite: AM 701.

AM 704 Aerothermochemistry  2½/0:3
Fundamental of chemical thermodynamics, fluid dynamics and
chemical kinetics. Applications to combustion and emission
phenomena, fluid lasers, plasmas and hypersonics. Prerequisi-
te: AM 701.

AM 705 Combustion I  2½/0:3
Chemical characteristics of flames. Topics covered include:
heat of formation and of reaction, phase and reaction equilib-
ria and adiabatic flame temperature and specie concentration
in stationary and flowing reacting systems. Chemical kinetics
of homogeneous and heterogeneous reacting systems.
Branching chain reactions and explosion limits are then de-
veloped. Prerequisite: AM 701

AM 706 Combustion II  2½/0:3
Physical characteristics of flames. Topics covered include:
the basic equations of aerothermo-chemistry, flame propagation
in initially mixed and premixed gases, laminar and turbulent
flame speeds, combustion of liquid droplets and sprays, com-
bustion of solid particles and flame spreading in solids, and
chemical reactions in boundary layers. Prerequisite: AM 705.

AM 709 Special Topics: Thermodynamics and Combustion*  2½/0:3
Topics of particular current interest in thermodynamics and
combustion. Prerequisite: AM advisor's approval.

AM 710 Convection  2½/0:3
Development and applications of laminar hydrodynamic and
thermal boundary layer equations for fluid media. Mechanics
of turbulence; formulation and analysis of turbulent hyd-
romechanics and thermal applications: natural convection and
film evaporation and condensation. Prerequisite: AM 740 or
equivalent.

AM 711 Convective Heat Transfer*  2½/0:3
Theory of free and forced convective systems. Equations for
heat transfer coefficients in compressible and incompressible
fluids are developed from boundary layer concepts. Applica-
tions to internal and external laminar and turbulent flows.
Prerequisite: AM 710.

AM 712 Conductive Heat Transfer*  2½/0:3
Theoretical development of transient and steady-state tempera-
ture distributions in finite and infinite solids. Appropriate
mathematical techniques introduced as required. Solids un-
dergoing phase change and two-dimensional fields. Prerequisi-
te: AM 203.

AM 713 Radiative Heat Transfer*  2½/0:3
Fundamentals of radiative mechanisms of energy transfer. De-
definitions of basic quantities. Equations of transfer, radiative
heat flux vector and conservation equations. Properties of sur-
faces and participating media. Applications to engineering
systems. Prerequisite: AM 203.

AM 714 Radiation Gas Dynamics*  2½/0:3
Conservation equations for gas flows with radiation transport.
Significant inviscid and viscous flows; one-dimensional flows
with radiative transport according to various optical properties
laminar flows with simple transport properties; laminar flows
with some complex properties and turbulent diffusive flows.
Prerequisite: AM adviser's approval.

AM 715 Heat Transfer  2½/0:3
Basic heat transfer mechanisms. Steady and unsteady con-
duction, including systems with internal heat sources, internal
and external forced and free convection, Radiation between
surfaces and in gases. Dimensional and boundary layer con-
siderations. Applications involving fins and heat exchangers.
Credit for AM 715 will not be granted if AM 203 was
taken. Prerequisite: AM adviser's approval.
Also listed under NU 715

AM 716 Reactor Heat Transfer*  2½/0:3
Heat transfer problems and solution techniques associated
with nuclear reactors including BWR, PWR, LMFBR and
HIGHTS. Representative core geometries and primary loop
components. Flow boiling phenomena, liquid metal heat trans-
ferr, combined convection and radiation gas flow: LOCA and
ECCS considerations. Prerequisite: AM 715 or AM 203.

AM 717 High-Performance Heat Exchangers*  2½/0:3
Heat exchanger requirements including need for augmenta-
tion. Review of extended surface concepts. Effectiveness-NTU
approach. Overall thermodynamic considerations. Basic heat
transfer relations; for laminar and turbulent internal flows.
Selection of exchanger configurations. Regenerators. Heat pumps. Prerequisite: AM 203 or AM 718.

AM 718 Multiphase Flows with Heat Transfer* 2/½:0:3

AM 720 Special Topics: Heat Transfer* 2/½:0:3
Topics of particular current interest in heat transfer. Prerequisite: AM adviser's approval.

AM 731 Analytical Methods in Thermal and Fluid Mechanics* 2/½:0:3
Classification of differential equations of fluid and thermal mechanics. Methods of characteristics for supersonic flow and wave propagation. Potential methods including complex variable applications for transform techniques for convection and conduction. Prerequisites: AM adviser's approval.

AM 732 Computational Methods in Thermal and Fluid Mechanics* 2/½:0:3
Review of numerical analyses: Finite difference approximations, error and stability analyses, numerical dispersion and damping, matrix inversion methods, implicit and explicit procedures, SOR, ADI, hopscotch and direct solvers for evaluating linear and nonlinear diffusion and convection problems. Prerequisite: AM adviser's approval.

AM 740 Principles of Fluid Dynamics 2/½:0:3
Conservation laws of mass momentum and energy. Elements of potential theory and gas dynamics. Applications of inviscid flow to simple internal and external geometries; control volume and differential approach to fluid dynamic problems. Prerequisite: AM adviser's approval.

AM 741 Compressible Flow* 2/½:0:3
Subsonic, transonic and supersonic flows over two dimensional and axisymmetric bodies. Shock wave development in both one-dimensional unsteady and two-dimensional steady flow systems. Internal and external flows are considered. Prerequisite: AM 740.

AM 742 Viscous Flow* 2/½:0:3
Introduction to molecular and macroscopic transport, concepts of stress and strain, and derivation of the Navier-Stokes equations. Application to problems of diffusion, boundary layers and slow motion. Analytic and numerical methods are presented. Prerequisite: AM 710.

AM 743 Turbulent Flow* 2/½:0:3
General theories of turbulence, basic concepts, transition, homogeneous turbulence, analysis of turbulent shear flows, turbulent heat and mass transfer, experimental methods. Prerequisite: AM 710.

AM 744 Viscous Compressible Flow* 2/½:0:3
Effects of compressibility in both subsonic and supersonic flows on boundary layer behavior including heat transfer effects, diffusion, numerical approaches to solving these problems. Quasi-one-dimensional flows in ducts and channels including effects of viscosity, heat transfer, mass transfer. Prerequisites: AM 741 and AM 742.

AM 745 Hydrodynamics* 2/½:0:3
General theorems of hydrodynamics. Analytical techniques including formulation of boundary conditions. Analysis of hydrofoils, planning, cavitating propellers and hydrofoils, flow about partially submerged bodies, wave drag, underwater propulsion, cascades, surface impact, geophysical problems. Prerequisite: AM adviser's approval.

AM 746 Fluid Dynamics of Rotating Machinery* 2/½:0:3

AM 748 Dynamics of Rarefied Gases* 2/½:0:3
Treatment of fundamental gas kinetics and introduction of pertinent physical and mathematical concepts. Phenomenology and analysis of low-density flows of neutral and ionized gases. Selected applications to flight problems, heat transfer and vacuum technology. Prerequisite: AM adviser's approval.

AM 749 Magnetohydrodynamics* 2/½:0:3
Dynamics of electrically conducted gases in electric and magnetic fields. Moving fields and electromagnetic equations. Thermodynamics of fluids in electromagnetic fields. Magnetohydrodynamics, characteristics, waves, shock waves. Applications: MHD propulsion and power generation. Prerequisite: AM adviser's approval.

AM 750 Ocean Waves and Tides* 2/½:0:3
Generation, propagation and decay of surface waves and swell, internal waves, Rossby waves, seiches, storm surges, tides. Relations between theory and observation. Methods of observation. Prerequisite: AM adviser's approval.

AM 751 Aerodynamics of Urban Environment I* 2/½:0:3
Aerodynamic forces and pressures on non-aeronautical shapes including vehicles, buildings, other structures. Unsteady forces and dynamic interaction with structures. Motion and thermal characteristics of atmospheric boundary layer. Air flow and thermal characteristics over urban regions and various topographical configurations. Prerequisite: Adviser's approval.

AM 752 Aerodynamics of Urban Environment II* 2/½:0:3
Travel and dispersion of atmospheric pollutants. Puriﬁcation and dispersion theories with application to uniform and nonuniform atmospheres. Effects of boundary configurations of various scales; buildings, urban regions, bodies of water, mountains, valleys. Prerequisite: AM 751.

AM 753-754 Wave Turbulence I, II* each 2/½:0:3
Analysis of inhomogeneous and nonstationary turbulent fields. Kinetic and fluid dynamic descriptions of many particle systems at both quasilinear and nonlinear levels. Wave-particle and wave-wave treated instabilities as collision processes both classically and quantum theoretically. Determination of self-consistent kinetic equations for both particles and waves. Applications to space-time evolution of coupled background and turbulent wave fields. Prerequisite: Adviser's approval.

AM 755 Experimental Methods in Thermal and Fluid Mechanics* 2/½:0:3
Measurement principles including mechanical, electrical, electromagnetic, thermal and optical techniques. Application to measurements of forces, pressures, heat transfer, velocity and electron density. Schlieren, interferometry, laser, Raman scattering, etc. Prerequisites: AM adviser's approval.

AM 759 Special Topics: Fluid Mechanics* 2/½:0:3
Topics of particular current interest in fluid mechanics. Prerequisite: AM 740.

AM 760 Energy Conversion* 2/½:0:3
Energy resources, modes of energy conservation and principles of energy conversion technology applied to electrical
power generation, transportation systems, environmental control and cryogenic systems. Combined cycles and processes and "total energy systems". Environmental considerations. Prerequisite: AM 701.

AM 763 Solar Thermal Engineering I 2/1:0:3
Basic course in the use of solar radiation for heating of buildings, swimming pools, domestic hot water and low temperature processes. Direct, diffuse and ground-reflected solar radiation, sun angles, active and passive solar thermal engineering, building heat losses, flat plate collector design, construction and thermal efficiency, fluid friction, heat storage design, heat distribution systems, domestic water heaters, system performance simulations, economics of solar heating. Prerequisite: undergraduate engineering degree.

AM 764 Solar Thermal Engineering II 2/1:0:3
Extension of AM 763 to more advanced solar heating topics plus cooling and dehumidification. Heat transfer and storage in massive walls, double shell houses, Trombe walls, residential and commercial greenhouses, seasonal solar heating performance estimates. Vapor compression refrigeration cycle, solar assisted heat pump systems, absorption refrigeration cycles, heat engines, solar-driven air conditioners, solar dehumidifiers, concentrating solar collectors. Use of reflectors to improve system performance. Prerequisite: AM 763.

AM 765 Energy Conservation and Environmental Control* 2/1:0:3

AM 769 Special Topics: Energy Conversion* 2/1:0:3
Topics of particular current interest in energy conversion. Prerequisite: AM adviser's approval.

AM 771 Computational Geometry for Computer-Aided Design 2/1:0:3

AM 772 Computer-Aided Design 2/1:0:3
Introduction to concepts and potentials of computer-aided design. Role of interactive computer graphics in CAD. Review of hardware systems and existing software packages. Geometric modeling and object hierarchy. Raster algorithms and display architecture. 3D modeling, hidden surfaces treatment, of CAD systems. Design, programming, and use of CAD systems. A project involving the development of CAD systems is required. Prerequisite: AM 332 or AM 771.

AM 801 Trajectories and Orbits* 2/1:0:3
Two-body problem. Formulas for orbital motion, optimum orbit transfer and rendezvous problem, interplanetary trajectories. Re-entry trajectories, maximum acceleration and heat transfer, effect of aerodynamic lift. Prerequisite: AM adviser's approval.

AM 802 Space Mechanics* 2/1:0:3
Treatment of celestial mechanics including n-body problem, 3-body problem, restricted 3-body problem. Jacobian integral and applications, including effects of atmospheric drag, oblateness of the earth, and presence of additional bodies, motion of the moon. Prerequisite: AM 801.

AM 803 Vehicle Dynamics I* 2/1:0:3
Aerospace flight mechanics of airplanes, quasisteady and dynamic performance in various flight regimes, energy methods. Space vehicles, partial motion in central force field, launch and re-entry trajectories. Land and seaborne vehicles. Automobile, tracked vehicles, ship and GEM vehicles. Prerequisite: AM adviser's approval.

AM 804 Vehicle Dynamics II* 2/1:0:3

AM 806 Physics of the Atmosphere 2/1:0:3

AM 810 Theory of Propulsion* 2/1:0:3
Principles of modern propulsion based on chemical energy sources: Air-breathing engines, combustion thermodynamics, flows with chemical reactions, thermochemistry of solid and liquid rocket engines. Engineering parameters in engine design. Prerequisite: AM adviser's approval.

AM 811 Engine-Airplane Integration* 2/1:0:3
Basic concepts underlying interaction of power plant and airframe flow fields. Air inlet and jet exhaust region design requirements: estimation of net axial forces. Uses of thrust vectored for attainment of VISTOL performance and for improved high-speed maneuvering capabilities. Prerequisite: AM adviser's approval.

AM 812 Helicopter Theory* 2/1:0:3

AM 819 Special Topics: Aeronautics and Astronautics* 2/1:0:3
Topics of particular current interest in aeronautics and astronautics. Prerequisite: AM adviser's approval.

AM 891-904 Guided Readings I, II, III, IV each 3 units
Open to qualified graduate students interested in special advanced topics. Directed study including analytical work and/or laboratory investigations. Prerequisite: written permission of departmental head.

AM 927 Energy Policy Issues
See Energy Program for details (ES 927)

AM 928 Energy Resource Distribution and Conversion Technology
See Energy Program for details (ES 928)

AM 935 Engineering Projects Related to Public Administration each 3 units
See Cooperative Program with New York University's Graduate School of Public Administration for details.
SEMINAR, PROJECTS, THESIS AND DISSERTATION

AM 971-972 Seminar in Mechanical and Aerospace Engineering

Recent developments through lectures by representatives from industry, research, educational institutions. Discussion from floor. Satisfactory attendance required of master’s or engineering students for two semesters; four additional semesters required of Ph.D. students.

AM 996 Project each 3 units

Engineering project pursued with guidance of faculty member. Project title to be submitted in writing to department head and advisor appointed. May be extended to thesis with project advisor's recommendation. Credit only upon completion of project. Reregistration fee: 3-unit charge. Prerequisite: degree status.

AM 997 M.S. Thesis each 3 units

Master's thesis to present results of original investigation in field of student's specialty. Thesis an extension of AM 996; on recommendation of project advisor. Continuous registration required. Maximum of twelve units of AM 996-997 counted toward degree. Reregistration fee: 3-unit charge. Prerequisite: AM 996.

AM 998 Engineer Project each 3 units

Analytical experimental or design project under guidance of faculty member. Oral examination on project and related topics required of candidate. Continuous registration required until satisfactory project completed. Minimum of six, maximum of twelve units of AM 998-999 counted toward degree. Reregistration fee: 3-unit charge. Prerequisite: post-master status.

AM 999 Ph.D. Dissertation each 3 units

Doctor's dissertation involving independent study and original contributions in field of specialization. Oral examination on subject of dissertation and related topics required. Minimum of 24 units; also continuous registration at minimum of 3 units per semester required until dissertation completed. Reregistration fee: 3-unit charge. Prerequisite: degree status.

FACULTY

Pasquale M. Sforza, Professor and Head Mechanical and Aerospace Engineering

B.Ae.E., M.S., Ph.D., Polytechnic Institute of Brooklyn

Theoretical and experimental fluid dynamics, fluid power engineering

Vito D. Agosta, Professor

B.M.E., Polytechnic Institute of Brooklyn, M.S., University of Michigan, Ph.D., Columbia University

Propulsion, heat power, heat transfer

Anthony E Armenakas, Professor

B.S., Georgia Institute of Technology, M.S., Illinois Institute of Technology; Ph.D., Columbia University

Vibration, dynamic analysis of structures, fracture

William Blesser, Professor

B.M.E., Rensselaer Polytechnic Institute; M.E.E., Polytechnic Institute of Brooklyn

Bioengineering, instrumentation, control systems

Martin H. Bloom, Institute Professor

B.M.E., M.S., Ph.D., Polytechnic Institute of Brooklyn

Fluid and thermal studies, aerospace engineering, energy conservation

Robert J. Cresci, Professor

B.Ae.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

Gas dynamics, heat and mass transfer, industrial aerodynamics

John R. Curreri, Professor

B.M.E., M.E.E., Polytechnic Institute of Brooklyn; M.S., Adelphi University

Nonlinear vibrations, stress analysis, earthquake response of structures

Burton Erickson, Professor

B.Ae.E., M.S., Polytechnic Institute of Brooklyn, M.S., Adelphi University

Experimental stress analysis, mechanics

Murray Imber, Professor

B.S., University of Illinois; M.S., Eng. Sc. D., Columbia University

Energy conversion, heat transfer, applied mathematics

Joseph Kempner, Professor

B.Ae.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

Structural analysis, shell theory, structural dynamics

Jerome M. Klosner, Professor

B.C.E., CCNY, M.S., Columbia University, Ph.D., Polytechnic Institute of Brooklyn

Structural dynamics, fluid-structure interaction, thermal stress analysis

Samuel Lederman, Professor

Dipl. Ing., Technical University of Munich (Germany); M.E.E., Polytechnic Institute of Brooklyn

Wind and shock tunnel testing, diagnostics of fluids, microwaves, spectroscopy, lasers, plasma

Mansuk Lee, Industry Professor

B.S., M.S., Massachusetts Institute of Technology, M.E., Columbia University

Computer graphics, CAD, heat transfer

Morris Morduchow, Professor

B.A., Brooklyn College; B.Ae.E., M.Ae.E., D.Ae.E., Polytechnic Institute of Brooklyn

Fluid dynamics, solid dynamics, numerical analysis

Gino Moretti, Professor

Ph.D., University of Turin (Italy)

Fluid mechanics, numerical techniques

Wheeler K. Mueller, Jr., Professor

B.S., Iowa State College, M.S., Ph.D., University of Illinois

Heat transfer, thermodynamics, energy conversion

Sebastian V. Nardo, Professor and Administrative Officer, Farmingdale

B.M.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

Structural mechanics, dynamics, solar energy
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Education</th>
<th>Specializations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huo-Hai Pan</td>
<td>Professor</td>
<td>B.S., National Southwest Associated University (China); M.S., Texas A&amp;M, M.S., Kansas State University; Ph.D., University of California (Berkley)</td>
<td>Solid mechanics, rational design, applied mathematics</td>
</tr>
<tr>
<td>Sharad A. Patel</td>
<td>Professor</td>
<td>B.Sc., Barnes Hindu University (India), M.A.E., Ph.D., Polytechnic Institute of Brooklyn</td>
<td>Solid mechanics, creep, structural analysis</td>
</tr>
<tr>
<td>Frank J. Romano</td>
<td>Professor and Administrative Officer</td>
<td>Brooklyn</td>
<td>Solid mechanics, structures, thermodynamics</td>
</tr>
<tr>
<td>Bernard W. Shaffer</td>
<td>Professor</td>
<td>B.M.E., CCNY, M.S., Case Institute of Technology, Ph.D., Brown University</td>
<td>Rational design, elasticity, plastic stress analysis</td>
</tr>
<tr>
<td>Simon Slutsky</td>
<td>Professor</td>
<td>B.C.E., CCNY, M.S., Columbia University; Ph.D., Polytechnic Institute of Brooklyn</td>
<td>Urban noise, engine noise, vibrations</td>
</tr>
<tr>
<td>William P. Vafakos</td>
<td>Professor</td>
<td>B.M.E., M.M.E., Ph.D., Polytechnic Institute of Brooklyn, J.D., Brooklyn Law School</td>
<td>Solid mechanics, structures</td>
</tr>
<tr>
<td>Philip Abramti</td>
<td>Associate Professor</td>
<td>B.M.E., M.S., Polytechnic Institute of Brooklyn</td>
<td>Mechanical analysis and design, sport product engineering</td>
</tr>
<tr>
<td>Philip Chaikin</td>
<td>Associate Professor</td>
<td>B.M.E., CCNY, B.M.E. New York University</td>
<td>Graphics, computer programming</td>
</tr>
<tr>
<td>Robert Corry</td>
<td>Associate Professor</td>
<td>A.B., Columbia College, B.S., M.S., Ph.D., Columbia University</td>
<td>Applied instrumentation, servomechanisms</td>
</tr>
<tr>
<td>Jesse F. Crump</td>
<td>Associate Professor</td>
<td>B.S., M.D., University of Nebraska</td>
<td>Physiology, bioengineering, medical instrumentation</td>
</tr>
<tr>
<td>Morris P. Isom</td>
<td>Associate Professor</td>
<td>A.B., Harvard University, M.S., Massachusetts Institute of Technology, Ph.D., Princeton University</td>
<td>Acoustics, gas dynamics, applied mathematics</td>
</tr>
<tr>
<td>August R. Krenkel</td>
<td>Associate Professor</td>
<td>B.S., M.S., Massachusetts Institute of Technology</td>
<td>Atmospheric flight dynamics, applied aerodynamics, aircraft design</td>
</tr>
<tr>
<td>Richard S. Thorsen</td>
<td>Associate Professor</td>
<td>B.M.E., CCNY, M.M.E., Ph.D., New York University</td>
<td>Heat transfer, nuclear reactor safety, solar energy, CAD</td>
</tr>
<tr>
<td>Jack E. Werner</td>
<td>Associate Professor</td>
<td>B.S., M.S., Massachusetts Institute of Technology</td>
<td>Low-speed aerodynamics, shock waves, fluid mechanics</td>
</tr>
<tr>
<td>Tsu-Chin Chu</td>
<td>Assistant Professor</td>
<td>B.S., Nat’l Cheng Kung University (Taiwan); M.S., Auburn University; Ph.D., University of South Carolina</td>
<td>Computer graphics, CAD/CAM, stress analysis</td>
</tr>
<tr>
<td>Chih-Sheng Wei</td>
<td>Assistant Professor</td>
<td>B.S., Nat’l Chung Hsing University (Taiwan); M.S., State University of New York, Buffalo; Ph.D., Georgia Institute of Technology</td>
<td>Computer graphics, CAD/CAM, heat transfer</td>
</tr>
<tr>
<td>Joanne DiMarco</td>
<td>Adjunct Lecturer</td>
<td>B.A., Queens College (CCNY); M.A., State University of New York</td>
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<tr>
<td>Robert DiMarco</td>
<td>Adjunct Lecturer</td>
<td>B.S., M.S., Polytechnic Institute of Brooklyn</td>
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<tr>
<td>Richard LaRosa</td>
<td>Adjunct Lecturer</td>
<td>B.S., M.S., D.E., Polytechnic Institute of Brooklyn</td>
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<tr>
<td>Bernard Roth</td>
<td>Adjunct Lecturer</td>
<td>B.M.E., M.S., CCNY</td>
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<tr>
<td>John Sposito</td>
<td>Adjunct Lecturer</td>
<td>B.S., M.S., Polytechnic Institute of Brooklyn</td>
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<tr>
<td>Steven Vitale</td>
<td>Adjunct Lecturer</td>
<td>B.M.E., M.M.E., M.C.E., Polytechnic Institute of New York</td>
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</table>
METALLURGY: PHYSICAL AND ENGINEERING

Human civilization dawned with the transition from the stone age to the iron age. Ever since, metallic materials have been the pacesetters of our technological advancement. Metallurgists are specialists in the most effective utilization of metals and alloys. They are vital to the solution of problems arising from the intensive quest for superior materials in our rapidly advancing technological age. During the last two decades, we have witnessed an increasing demand for such familiar materials as high-strength steels, aluminum, magnesium and copper alloys, and the utilization of some less common metals such as titanium, beryllium and molybdenum. Yet we have utilized only a fraction of the theoretical potentials of metallic materials. Thus a challenge remains for imaginative individuals to probe, understand, fabricate and use metallic materials semiconductors and composites in fields ranging from electronic devices and integrated circuits to new energy production processes, to chemical production and space environment. The broad field of metallurgy may be divided into several areas of specialization. The most important of these are physical and engineering metallurgy, which are emphasized at Polytechnic.

Physical Metallurgy

Physical metallurgy is concerned with the study and understanding of fundamental properties of materials and how these properties are related to the microscopic and macroscopic behavior of metals and alloys. Chemical composition, atomic bonding, crystal structure and microscopic imperfections are correlated with the strength and other physical and chemical properties of metals and alloys. Because the same basic concepts relating microstructures to physical properties also apply to other classes of solids, metallurgists often find themselves involved with many nonmetallic materials such as ceramics and glasses, semiconductors, ionic solids and even polymers.

Engineering Metallurgy

In engineering metallurgy, attention is focused directly on the engineering application of metallic materials in the electronic, aerospace, energy and chemical production and transportation industries. Metallurgical engineers play a vital role in materials selection and process optimization. They have a thorough knowledge of existing metallic materials, their properties and limitations. Borrowing fundamental knowledge from physical metallurgy, they are constantly in search of a new and better material to improve a process or a product. Some of the areas in which a metallurgical engineer works are: prevention of corrosion and environmental degradation, welding, brazing and joining of metals and alloys, failure analysis and product reliability and safety, quality control, materials characterization and alloy development.

Metallurgists may work in research and development, plant operations or consulting. Further, metallurgists contribute to the progress in oceanography, medical prosthetics, dental materials, environmental protection and electronic devices.

Programs of study in this department lead to the degrees of bachelor of science, master of science and engineer in metallurgical engineering and to the degree of doctor of philosophy in physical metallurgy, materials science and metallurgical engineering and materials science. The undergraduate program is accredited by the Accreditation Board for Engineering and Technology.

UNDERGRADUATE PROGRAM

The program for full-time study is designed to establish a firm basis from which the graduate may proceed along any avenue of professional development from graduate study and research to industrial assignments. Scientific understanding and utilization of basic concepts—rather than dependence on purely factual knowledge—are the department's aim, providing the capability to solve present problems and the ability to keep pace with the technological advancements and increasingly complex problems of the future.

Specifically, the curriculum consists of 33 credits in mathematics, physics and chemistry, 24 credits in the humanities and social sciences, 60 credits in engineering sciences, material sciences, engineering design and systems, 9 credits of technical electives, 3 credits of free electives and 7 credits of thesis.

Students will have an opportunity to select physical metallurgy or metallurgical engineering technical electives. The materials science oriented student may choose the former program, while the student...
interested in the industrial aspects of materials may select the latter. The technical elective structure also allows students to branch out into interdisciplinary fields by taking courses in bioengineering, polymeric materials, physics or chemistry.

During their junior and senior years metallurgy students may broaden their programs by concentrating the technical elective sequence of 12 credits into one of three options: management, computer, or material science, as shown on the following page.

In addition to the above, students may (with adviser's approval) elect to substitute for thesis MT 496-497 (6 credits) applied computer courses: AM 331 Devices and Computational Methods in Computer-Aided Design (3 credits) and AM 332 Computer Graphics in Computer-Aided Design (3 credits).

Humanities and social science requirements for all engineering students are given in section on “Degree Requirements.”

The freshman and sophomore years of the metallurgical engineering curriculum may be taken at the Long Island Center. The junior and senior metallurgy courses are offered only on the Brooklyn campus. Any of the nonmetallurgy courses listed in the last two years may also be taken at the Long Island campus, provided they are offered.

Typical Course of Study for the Bachelor of Science Degree in Metallurgical Engineering

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Second Semester</th>
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<tbody>
<tr>
<td>First Semester</td>
<td>Hours/Week</td>
</tr>
<tr>
<td>ME 101 General Chemistry I</td>
<td>2 1/2 0 2 1/2</td>
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<tr>
<td>ME 111 General Chemistry Lab I</td>
<td>0 1 1/2 1/2</td>
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<tr>
<td>CH 101 College Composition</td>
<td>3 0 3</td>
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<tr>
<td>SS 104 Contemp. World History</td>
<td>3 0 3</td>
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<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
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<tr>
<td>PH 101 Intro Physics I</td>
<td>3 0 3</td>
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<tr>
<td>PE 101 Physical Education</td>
<td>0 2 0</td>
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<tr>
<td>Sophomore Year</td>
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<tr>
<td>AM 115 Eng. Mechanics</td>
<td>4 0 4</td>
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<tr>
<td>AM 101 Graphics</td>
<td>1 3 2</td>
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<tr>
<td>PH 103 Intro to Physics III</td>
<td>2 1/2 1 1/2 3</td>
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<tr>
<td>MA 103 Calculus III</td>
<td>3 0 3</td>
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<tr>
<td>PE 103 Physical Education</td>
<td>0 2 0</td>
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<tr>
<td>Junior Year</td>
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<tr>
<td>ME 101 Physical Metallurgy I</td>
<td>3 0 3</td>
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<tr>
<td>ME 102 Mech. Metallurgy I</td>
<td>3 3 4</td>
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<td>ME 104 Metallurgy Lab</td>
<td>0 6 2</td>
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<td>ME 405 Metallurgical Thermodynamics</td>
<td>3 0 3</td>
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<tr>
<td>Senior Year</td>
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<tr>
<td>ME 410 Solids State Metallurgy</td>
<td>3 0 3</td>
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<tr>
<td>ME 411 Fabrication Technology</td>
<td>3 0 3</td>
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<tr>
<td>ME 416 Electromet. &amp; Corrosion</td>
<td>2 3 3</td>
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<tr>
<td>ME 421 Metal Failure Analysis</td>
<td>2 3 3</td>
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<tr>
<td>ME 498 Thesis or Technical Elective</td>
<td>0 9 3</td>
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</table>

*The 12 credits of electives taken during the last three years comprise 9 credits of technical electives and 3 credits of free electives.

Total credits required for graduation: 136
**MANAGEMENT OPTION**

*Freshman and sophomore courses as in regular program*

<table>
<thead>
<tr>
<th>Junior Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
</tr>
<tr>
<td>MT 401</td>
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<td>0</td>
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<tr>
<td>MT 405</td>
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<td>3</td>
<td>0</td>
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<td>MG 300</td>
<td>Management Process</td>
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<thead>
<tr>
<th>Senior Year</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>MT 410</td>
<td>Solid State Metallurgy</td>
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</tr>
<tr>
<td>MT 411</td>
<td>Fabrication Technology</td>
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<tr>
<td>MT 416</td>
<td>Electromet. &amp; Corrosion</td>
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<tr>
<td>MT 421</td>
<td>Metal Failure Analysis</td>
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<td>MT 496</td>
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**COMPUTER OPTION**

*Freshman and sophomore courses as in regular program*

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<tr>
<th>Junior Year</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
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<td>Lab.</td>
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<td>MT 401</td>
<td>Physical Metallurgy I</td>
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<tr>
<td>MT 404</td>
<td>Metallurgy Lab.</td>
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<td>6</td>
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<td>MT 405</td>
<td>Met. Thermodynamics</td>
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<td>0</td>
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<tr>
<td>CS 253</td>
<td>Computer Programming II</td>
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<th>Senior Year</th>
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<tbody>
<tr>
<td>MT 410</td>
<td>Solid State Metallurgy</td>
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<tr>
<td>MT 411</td>
<td>Fabrication Technology</td>
<td>3</td>
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<tr>
<td>MT 416</td>
<td>Electromet. &amp; Corrosion</td>
<td>2</td>
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<tr>
<td>MT 421</td>
<td>Metal Failure Analysis</td>
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<tr>
<td>MT 496</td>
<td>Thesis or Technical Elective</td>
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<td>CS 253</td>
<td>Assembly and Machine Language Programming</td>
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**MATERIAL SCIENCE OPTION**

*Freshman and sophomore courses as in regular program*

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<tr>
<th>Junior Year</th>
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<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
<td>Cr.</td>
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<td>MT 401</td>
<td>Physical Metallurgy I</td>
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<tr>
<td>MT 402</td>
<td>Mechanical Metallurgy I</td>
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<tr>
<td>MT 404</td>
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<td>CM 122</td>
<td>Organic Chemistry</td>
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<td></td>
<td>Total</td>
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<td>MT 411</td>
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<td>Electromet. &amp; Corrosion</td>
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<td>MT 421</td>
<td>Metal Failure Analysis</td>
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<td>MT 496</td>
<td>Thesis or Technical Elective</td>
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<tr>
<td>CH 917</td>
<td>Introduction to Polymeric Materials</td>
<td>2</td>
</tr>
<tr>
<td></td>
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<td>18</td>
</tr>
</tbody>
</table>
GRADUATE STUDY

The Department of Physical and Engineering Metallurgy prepares students for the degrees of master of science and engineer in metallurgical engineering and doctor of philosophy in physical metallurgy, in materials science and in metallurgical engineering and materials science. The courses of study and research leading to these degrees are designed for students holding baccalaureate degrees in metallurgical engineering, but are open to those holding baccalaureate degrees in related disciplines if undergraduate deficiencies are removed.

Both fundamental and applied research are carried on within the department. Excellent facilities are available for work in electron microscopy, x-ray diffraction, deformation and fracture and other fields. Fundamental research is being carried out on alloy hardening, deformation and fracture, phase transformations, thermomechanical working and other topics. In applied research, the department is involved in studies of metallurgical materials for medical and dental applications, electronic applications and energy-related applications. The rules governing admittance to graduate studies are applicable to all students.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>MT 760-761</td>
<td>Seminar (attendance required two semesters)</td>
<td>3</td>
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<tr>
<td>MT 995</td>
<td>Project</td>
<td>6</td>
</tr>
<tr>
<td>Nine units from the following:</td>
<td></td>
<td></td>
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<tr>
<td>MT 600</td>
<td>Structure-Property Relationships in Materials</td>
<td>3</td>
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<tr>
<td>MT 610</td>
<td>Thermodynamics of Metals and Alloys</td>
<td>3</td>
</tr>
<tr>
<td>MT 620</td>
<td>Plastic Deformation and Fracture</td>
<td>9</td>
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<tr>
<td>MT 630</td>
<td>Theory of Metals</td>
<td>3</td>
</tr>
<tr>
<td>MT 640</td>
<td>Reactions in Solids</td>
<td>3</td>
</tr>
<tr>
<td>MT 650</td>
<td>Advanced Engineering Metallurgy</td>
<td>3</td>
</tr>
</tbody>
</table>

Selected electives in science, mathematics, economics or engineering, in consultation with department adviser, 6-18 or
MT 997 | Thesis | 12 |

Total 36

In order to be admitted to the master's program, an applicant must have the equivalent of a bachelor's degree in metallurgy or materials science. An applicant with a bachelor's degree in a field of science or engineering other than metallurgy or materials science may have to remove some undergraduate deficiencies as determined by the department adviser.

A graduate student enrolled in the master's program may elect to do a six-unit project, a 12-unit thesis, or under special circumstances take a series of recommended courses and pass an oral examination. A total of 36 units is required for the degree.

Part-time students enrolled for the M.S. degree in metallurgical engineering may elect to take the following groups of courses.

Required Subjects:  

<table>
<thead>
<tr>
<th>Take 9 units from:</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 600</td>
<td>Structure-Property Relationships</td>
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<tr>
<td>MT 610</td>
<td>Thermodynamics of Metals and Alloys</td>
</tr>
<tr>
<td>MT 620</td>
<td>Plastic Deformation and Fracture</td>
</tr>
<tr>
<td>MT 630</td>
<td>Theory of Metals</td>
</tr>
<tr>
<td>MT 640</td>
<td>Reactions in Solids</td>
</tr>
<tr>
<td>MT 650</td>
<td>Advanced Engineering Metallurgy</td>
</tr>
</tbody>
</table>

Metallurgy Department Electives  
Take 15 to 18 units from:
MT 603 | Electron Microscopy | 3 |
MT 621 | Special Topics: Fracture Mechanics | 3 |
MT 651 | Special Topics: Non-Destructive Testing | 3 |
MT 700 | Welding Engineering | 3 |
MT 705 | Semiconductor Technology | 3 |
MT 710 | Powder Metallurgy | 3 |
MT 715 | Corrosion & Oxidation | 3 |
MT 726 | Nuclear Reactor Materials | 3 |

Engineering & Science Electives  
Take 6 to 9 units from:
IE 611 | Statistical Quality Control | 3 |
IE 608 | Statistics | 3 |
MA 561 | Probability | 3 |
MG 600 | Management Process | 3 |
MG 601 | Organizational Behavior | 3 |
IE 685 | Reliability | 3 |

Project  
Take 3 to 6 units
MT 996 | Project | 3 to 6 |

Total 36

Metallurgical Engineering (Electronic Materials Concentration)

The following is a recommended sequence of required and elective courses for those graduate students who wish to concentrate on Electronic Materials:

Required Metallurgy Courses  

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Nine Units</td>
</tr>
<tr>
<td>MT 600</td>
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<tr>
<td>MT 630</td>
</tr>
<tr>
<td>MT 640</td>
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<tr>
<td>B. Twelve Units</td>
</tr>
<tr>
<td>MT 603</td>
</tr>
<tr>
<td>MT 705</td>
</tr>
<tr>
<td>MT 706</td>
</tr>
<tr>
<td>MT 707</td>
</tr>
</tbody>
</table>
Polymeric Materials Courses *

Twelve Units
CH 917 Introduction to Polymeric Materials 3
CH 926 Engineering Properties of Polymers 3
CM 771 Introductory Polymer Chemistry 3
CM 782 Macromolecules in the Solid State 3

* Undergraduate prerequisite in Organic Chemistry required.

MT 996 Project 3

Total: 36

REQUIREMENTS FOR THE ENGINEER DEGREE

Applicants for admission to this program must hold a master's degree (or equivalent) comparable in content to that of the department. This must include at least the equivalent of the required courses in the MT 600-650 series listed under the requirements for the master's degree. Applicants holding master's degrees for which the requirements vary substantially from those indicated above may be admitted to the engineer program if the deficiencies, as evaluated by the departmental graduate adviser, are removed during the time that the student is enrolled in the program.

No. Required Subjects Units
MT 621-622 Special Topics in Plastic Deformation and Fracture 6
MT 651-652 Special Topics in Advanced Engineering Metallurgy 6
MT 762 Seminar—presented by the student, critically reviewing a technical paper selected by the student with the approval of a faculty adviser —
Selected electives in science, mathematics, economics, or engineering, in consultation with departmental adviser, 18
MT 996 Project — 6

Total: 36

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

The requirements for the doctor's degree conform to the regulations in "Degree Requirements." Specific doctoral requirements are available from the departmental secretary in the publication Guide for Doctoral Students in Metallurgy.

A typical program consists of 30 units in the major field of physical metallurgy, a minor field in x-ray crystallography, a minor field in chemical physics, chemistry, theoretical mechanics, or other acceptable disciplines and 36 units of research for the doctoral dissertation.

UNDERGRADUATE COURSES

REQUIRED

MT 401 Physical Metallurgy I 3:0:3
Introduction to physical metallurgy. Relation of properties to microstructure; relation of mechanical properties to microstructure; nucleation and growth; phase diagrams; solidification; iron-carbon alloy systems; ferrous alloys. Prerequisites: PH 103, CM 102 and CM 112.

MT 402 Mechanical Metallurgy I 3:3:4

MT 403 Physical Metallurgy II 3:0:3

MT 404 Metallography Laboratory 0:6:2

MT 405 Metallurgical Thermodynamics 3:0:3

MT 406 Mechanical Metallurgy II 3:0:3

MT 407 Transport Methods in Metallurgy 3:0:3
Methods of engineering analysis applied to metallurgical systems. Simultaneous development of concepts of mass, energy, and momentum. Introduction to irreversible thermodynamics and its application to solid state diffusion. Prerequisites: MA 104 and PH 103.

MT 408 Physical Metallurgy Laboratory 0:6:2
Experiments to illustrate principles of physical metallurgy, including phase equilibria, recrystallization, solid-solution and precipitation hardening. Heat treatment of steel. Structure property relationships. Prerequisite: MT 404.

MT 410 Solid-State Metallurgy 3:0:3

MT 411 Fabrication Technology 3:0:3
MT 412 X-ray Diffraction 2:3:3

MT 413 Process Metallurgy 3:0:3

MT 416 Electrometallurgy and Corrosion 2:3:3

MT 421 Metallurgical Failure Analysis 1:8:3
Integrated knowledge of metallurgical principles applied to analysis of in-service failures of materials. Discussion of actual case histories. Laboratory assignments require students to prepare written reports and give oral presentations analyzing six in-service failures. Prerequisites: MT 404 and MT 406.

MT 423 Introduction to Ceramic Refractory Materials 3:0:3

MT 494 Informational Search 1:3:2
Preparation and presentation by student of a paper in the metallurgical engineering, physical metallurgy or material science literature. Topics may be related to bachelor's thesis.

MT 496-497 Bachelor's Thesis in Metallurgical Engineering MT 496-497 3 credits each 3 credits
A carefully planned original investigation on topic approved by head of department. Results must show conclusive evidence of student's ability to attack and solve problems pertaining to metallurgy. Regular conferences and written reports required during progress of work; examinations given mid-term and when thesis is completed. Prerequisite: MT 494.

TECHNICAL ELECTIVE COURSES

MT 409 Materials Selection 3:0:3

MT 414 Metallurgical Kinetics 3:0:3

MT 415 Metallurgy of Magnetic Materials 3:0:3

MT 417 Welding Metallurgy 3:0:3
Metallurgical aspects of welding. Theory and applications of arc, gas, resistance and solid state welding processes. Modern methods of procedure, control, tests, inspection. Examination of micro- and macro-structure of welds and adjacent areas. Applications of welding. Weldability criteria. Prerequisite: MT 302 or MT 401 or equivalent.

MT 418 Powder Metallurgy 3:0:3

MT 419 Strengthening Mechanisms in Metal 3:0:3

INTERDEPARTMENTAL COURSES

MT 301 Mechanical Behavior of Materials 2:3:3

MT 302 Metallurgy for Engineers 2:0:2
Introduction to atomic, microscopic and macroscopic structure of engineering materials. Effect of grain size and boundaries, work hardening and heat treatment on behavior of solids. Discussion of inelastic behavior, creep, fatigue, brittle and ductile fracture of metals.

MT 303 Nature and Properties of Structural Materials 1:3:2
Physical and mechanical properties of concrete, metals, plastics and asphaltic materials related to structure. Experimental investigation of mechanical properties of select structural materials and physical properties of cement and concrete mixes. Jointly developed and taught by civil and metallurgical engineering departments.

MT 304 Materials Science 2:3:3
Plastic behavior of single and polycrystalline materials. Deformation mechanisms. Effect of temperature and deformation on rate of plastic flow. Strain hardening. Dislocation theory. Fracture mechanics, toughness and crack propagation theories. Technical elective for aerospace, civil and mechanical engineering students. Prerequisite: MT 301 or MT 302 or MT 303 or consent of instructor.

MT 340 Manufacturing Processes 3:0:3
Mechanical behavior of metals. Properties of materials relating to fabrication methods. Metal cutting mechanics, cutting fluids, thermal and vibrational aspects of machining. Machinability criteria. Deformation processing, hot and cold, mechanisms of deformation. Unconventional processing, EDM and ECM. Numerical control. Metrology. Prerequisite: MT 301 or MT 401. Also listed under IE 340.

213
MT 375 Semiconductor Technology 3:0:3
Principal techniques involved in processing and fabrication of semiconductor devices and integrated circuits, including material preparation, junction forming, circuit integration, packaging. Prerequisites: EE 111 or MT 410 or equivalent.
Also listed under EE 119

MT 399 Senior Honors Work in Metallurgical Engineering credit to be arranged Independent work undertaken by qualified honors students in metallurgical engineering. Course material arranged by faculty steering committee.

MT 420 Engineering Materials 3:0:3
Also listed under CH 271

GRADUATE COURSES

MT 600 Structure-Property Relationships in Materials 2:1:0:3
Dependence of properties, e.g., mechanical and electrical, on structure of material. Crystalline vs. amorphous structure, occurrence and role of defects. Bonding and structure. Anisotropy of properties related to crystal symmetry. Polycrystal vs. single crystal vs. textured polycrystals. Prerequisite: MT 410 or equivalent.

MT 601-602 Special Topics in Structure-Property Relationships I, II* each 2:1:0:3
Advanced or specialized topics in structure-property relationships in materials presented at irregular intervals. Prerequisite: MT 600.

MT 603 Introduction to Electron Microscopy I 2:1:0:3

MT 604 Introduction to Electron Microscopy II 2:2:3

MT 610 Thermodynamics of Metals and Alloys 2:1:0:3
Review of fundamentals of classical and statistical thermodynamics with emphasis on solid state, phase equilibria in multiphase, multicomponent metallic systems; calculations of phase diagrams, thermodynamics of lattice defects and substructure. Prerequisite: MT 405.

MT 611-612 Special Topics in Thermodynamics and Statistical Mechanics of Metals, I, II* each 2:1:0:3
Advanced or specialized topics in thermodynamics and statistical mechanics of metals. Prerequisite: MT 610.

MT 620 Plastic Deformation and Fracture 2:1:0:3

MT 621-622 Special Topics in Deformation and Fracture I, II* each 2:1:0:3
Advanced or specialized topics in deformation and fracture. Prerequisite: MT 620.

MT 630 Theory of Metals 2:1:0:3
Quantum theory as applied to metals and alloys, theories of thermal properties of metals, theory of alloy phases, theories of electrical conductivity and magnetic properties of metals. Advanced or specialized topics in metals and alloys. Prerequisite: MT 410 or equivalent.

MT 631-632 Special Topics in Theory of Metals I, II* each 2:1:0:3
Advanced or specialized topics in theory of metals. Prerequisite: MT 630.

MT 640 Reactions in Solids 2:1:0:3
Study of mechanisms and kinetics of diffusion-controlled and diffusionless phase transformations in solid metallic systems; theories of precipitation, of grain boundary migration and grain growth, of eutectoid transformations and metalurgical transformation. Prerequisite: MT 414.

MT 641-642 Special Topics in Reactions in Solids I, II* each 2:1:0:3
Advanced or specialized topics in reactions in solids. Prerequisite: MT 640 or instructor's consent.

MT 650 Advanced Engineering Metallurgy 2:1:0:3
Requirements for—resistance to stress, oxidation and corrosion, and to structural instability in metals and alloys for low-, normal- and high-temperature service, theories of high-temperature deformation and fracture, of alloy design and design of alloys for challenging environments. Prerequisite: MT 405.

MT 651-652 Special Topics in Advanced Engineering Metallurgy I, II* each 2:1:0:3
Advanced or specialized topics in advanced engineering metallurgy presented at regular intervals. Prerequisite: MT 405.

MT 700 Welding Metallurgy 2:1:0:3
Analysis of process variables affecting joining techniques. Study of arc characteristics, heat flow, gas-metal interactions, solidification mechanics, residual stress effects, distortion control. Application of solid-phase bonding, electron and laser welding. Weldability criteria for ferrous and nonferrous alloys. Prerequisite: instructor's consent.

MT 705 Semiconductor Technology 2:1:0:3
Also listed under EL 644

MT 706 Magnetism and Magnetic Materials* 2:1:0:3
### MT 707 Thin Film Technology 2½:0:3
Preparation, structure, evaluation and properties of thin films: metallic, semiconductor and dielectric film techniques, nucleation and growth considerations, epitaxy, and metastable configurations. Prerequisite: instructor's consent.

### MT 708 Semiconductor Materials and Devices 3:0:3
Analysis of the nature of semiconductor materials stressing the interrelations among the band structure, chemistry and microstructure of materials. Elemental, compound, amorphous and polymeric semiconductors are covered. Examples of applications of materials for devices are given to illustrate how materials properties are matched to device characteristics for optimum performance.

### MT 709 Semiconductor Technology 3:0:3
Study of the process technology used to produce semiconductor devices and integrated circuits. Emphasis is on silicon technology; bipolar, MOS, and VLSI processes. The process requirements are first defined in terms of the circuit structure; i.e., concentration profiles, topographical layout as through diffusion, ion implantation, oxidation, photolithography, metallization, interconnection, and packaging to final test are analyzed. The impact of process design rules are pointed out. Prerequisite: MT 708 or permission of instructor.

### MT 710 Powder Metallurgy 2½:0:3
Fundamental treatment of powder metallurgy covering theoretical and practical aspects of subject. Production of metal parts from powder, review of commercial applications. Theories of metal synthesis, compacting, consolidation and sintering. Important patents and commercial processes Colloquium. Prerequisite: MT 405 or instructor's consent.

### MT 715 Corrosion and Oxidation Mechanisms in Metals 2½:0:3

### MT 725 Noble Metal Metallurgy 2½:0:3
Crystal structure and phase equilibria for noble metal alloy systems. Mechanical, electrical, magnetic and optical properties for various alloy systems. Criteria for corrosion and tarnish resistance. Fabrication, joining and application of noble metal alloys. Prerequisite: instructor's consent.

### MT 726 Metallurgy of Nuclear Reactor Materials 2½:0:3
Study of material requirements for basic parts of nuclear reactors. Metallurgy of fuels, moderators, control and construction materials. Description of handling and fabricating techniques. Prerequisite: instructor's consent.

### MT 727 Bioengineering Metallurgy 2½:0:3
Selection and application of metals and alloys for use in body environment. The body as corrosive environment. Examination of major problem areas. Principles and techniques for preparation of dental amalgams and other alloys. Design of alloys for biomaterial applications. Prerequisite: instructor's consent.

### MT 728 Survey of Metallurgical Principles 2½:0:3
Survey of metallurgical principles. Crystal structure, alloying, phase diagrams, diffusion phenomena, mechanical deformation of metals and alloys, recrystallization, age hardening. Prerequisite: instructor's consent.

### MT 731 Seminar in Metallurgical Engineering 0:2½:0:3
Recent progress in field of metallurgical engineering given in lectures by engineers from industry, research and educational institutions. One or more seminar topics from current literature in metallurgical field assigned each student for presentation. Students taking course expected to read in each of assigned topics as to be conversant with topic presented. (Attendance required for two semesters. Part-time students may substitute a three-unit metallurgy course.)

### MT 732 Seminar in Metallurgical Engineering 2½:0:3
Preparation and presentation by student of seminar on some topic of metallurgical engineering, in which student critically reviews technical paper selected by student with approval of faculty adviser. For students enrolled in engineer in metallurgical engineering degree program.

### MT 733 Seminar in Metallurgical Engineering 0:2½:0:3
Preparation and presentation by student of seminar on some topic of metallurgical engineering, in which student critically reviews technical paper selected by student with approval of faculty adviser. For students enrolled in doctoral program.

### MT 734 Seminar in Metallurgical Engineering 2½:0:3
See Energy Program for details.

### MT 735 Seminar in Metallurgical Engineering 2½:0:3
See Energy Program for details.

### MT 736 Seminar in Metallurgical Engineering 3:0:0:3
See Cooperative Program with New York University’s Graduate School of Public Administration for details.

### MT 737 Seminar in Metallurgical Engineering 3-6 units
Independent project demonstrating professional maturity and graduate-level knowledge completed with guidance of departmental adviser. Report includes critical analysis and interpretation of pertinent literature and should represent worthwhile contribution to the field. Oral final examination and project report required.

### MT 738 Seminar in Metallurgical Engineering 3-12 units
Expansion of project study to thesis level with approval of division head. Regular conference and reports during thesis investigation required.

### MT 739 Seminar in Metallurgical Engineering 3-6 units
Engineering project at post-master's level pursued with guidance of faculty member. Candidate required to take oral examination on subject matter of project and related topics.

### MT 740 Seminar in Metallurgical Engineering 3-6 units
Dissertation presents results of original research in area of physical metallurgy. Work must demonstrate originality and creativity and should be worthy of publication in recognized scientific journals. Candidate must take oral examination on thesis subject and related topics. Minimum of 36 units required.
FACULTY

George Fischer, Professor of Metallurgy and Head of Physical and Engineering Metallurgy
B Met.E., M Met.E., Polytechnic Institute of Brooklyn
Corrosion and welding metallurgy

Irving Cadoff, Professor of Metallurgy
B.M.E., CCNY, M.M.E., D.Eng Sc., New York University
Electronic materials, liquid metal embrittlement, thin film epitaxy

Louis S. Castleman, Professor of Metallurgy
S.B., Sc.D., Massachusetts Institute of Technology
Diffusion in solids, biomaterials

Carmine D’Antonio, Professor of Metallurgy
B Met.E., M Met.E., Polytechnic Institute of Brooklyn
Mechanical properties, thin films, failure analysis

Harold Margolin, Professor of Metallurgy
B.Eng., M.Eng., D.Eng., Yale University
Plastic deformation and fracture, titanium metallurgy, fatigue of metals and alloys

Homi S. Daruvala, Associate Professor of Metallurgy
M.A., M.Sc., LL.B., Bombay University (India);
B.S.E., M.S.E. (Chem. Eng.), M.S.E. (Met.), University of Michigan,
D.Ch.E., Polytechnic Institute of Brooklyn
Electrochemistry, materials processing and unit operations, ordering reactions

Said Nourbakhsh, Assistant Professor of Metallurgy
B.S., Arya-Mehr University of Technology (Iran); Ph.D.,
Leeds University (England)
Phase transformations, electron microscopy and mechanical behavior

Henry H. Hausner, Research Professor of Metallurgy
E.E., Dr.Eng., Technical University (Vienna, Austria)
Powder metallurgy, powder technology

ADJUNCT FACULTY

Simon D. Strauss, Distinguished Visiting Professor of Metallurgy and Fellow of the Polytechnic

Devendra Gupta, Adjunct Professor of Metallurgy
B.Sc., Delhi University (India); B.Sc., Banaras Hindu University (India); M.S., New York University;
Ph.D., University of Illinois

Robert Rosenberg, Adjunct Professor of Metallurgy
B.S., Drexel University; M.S., Ph.D., New York University

George Stern, Adjunct Professor of Metallurgy
B.Ch.E., CCNY; M.S., University of Michigan

John R. Weeks, Adjunct Professor of Metallurgy
M.S., Colorado School of Mines; M.S., Ph.D., University of Utah

Ernest Levine, Adjunct Associate Professor of Metallurgy
B. Met. E., Rensselaer Polytechnic Institute; Ph.D.,
New York University

Sankar Sastri, Adjunct Associate Professor of Metallurgy
B.S., Indian Institute of Science; M.S., M.E., Columbia University,
Ph.D., Polytechnic Institute of New York

James Lloyd, Adjunct Instructor of Metallurgy
B.S., M.S., Ph.D., Stevens Institute of Technology

Anthony J. Vecchio, Lecturer of Metallurgy
M Met.E., Polytechnic Institute of Brooklyn

EMERITUS FACULTY

John P. Nielsen, Professor Emeritus of Metallurgy
M.E., Ph.D., Yale University
Precious metals and alloys, grain growth and recrystallization, dental materials
MILITARY SCIENCE

Through the Reserve Officers Training Corps (ROTC) the U.S. Army gains officers with diverse educational backgrounds and contemporary ideas. ROTC graduates have the chance to use their ideas in positions of leadership and enable the Army to remain aligned with our ever-changing society.

ROTC enhances a student's education by providing unique leadership and management experience found in only a few college courses. It helps develop self-discipline, physical stamina and poise. Students develop qualities basic to success in any worthwhile career. They earn commissions in the U.S. Army while earning their college degrees.

OFFICER EDUCATION PROGRAM

The four-year Army ROTC program is divided into two parts—the basic course and the advanced course.

Basic Course — The basic course is usually taken in the freshman and sophomore years. No military commitment is incurred during this time, and students may withdraw at any time through the end of their second year. Subjects cover the following areas: first aid, national defense, drill, physical conditioning, map reading, survival techniques, mountaineering, tactics, marksmanship and leadership development.

Various social and professional enrichment activities are available in conjunction with the military science program. Necessary textbooks and materials are furnished without cost to the student. Students who participate in the basic course may be excused from physical education requirements.

All students in the basic course are organized into the ROTC Student Battalion. Some mandatory Saturday or weekend training is included in the coursework. Uniforms may be issued (a deposit is required) and students are required to wear them to some classroom and weekend training.

Advanced Course — The advanced course, normally taken in the final two years of college. Instruction includes further leadership development, organization and management techniques, basic military hands-on skills, tactics, administration, military history and the military justice system.

A paid six-week advanced camp is held during the summer between the junior and senior years. This camp permits cadets to put into practice the principles and theories they have acquired in the classroom. It also exposes them to the conditions of Army life in a tactical or field environment.

All cadets in the advanced course receive uniforms, necessary military science textbooks and pay for Advanced Camp ($600). U.S. citizens also receive a living allowance up to $1,000 each school year.

To be selected for the advanced course, a student must:

1. Be a citizen of the United States. Permanent residents may participate in the advanced course and obtain a commission once they obtain their citizenship, but they will not receive the living allowance until they obtain U.S. Citizenship.

2. Qualify for appointment as a second lieutenant prior to reaching 30 years of age.

3. Be approved by the professor of military science.

4. Successfully pass a prescribed medical examination.

5. Successfully pass an educational-level examination and a leadership assessment program.

6. Have successfully completed the two-year basic course or its equivalent.

THE TWO-YEAR PROGRAM

The two-year program is designed for undergraduate and graduate students who have not taken Army ROTC during their first two years and have two years remaining in school. Students can take advantage of this opportunity by successfully completing a paid six-week basic camp after their sophomore year and enrolling in the ROTC advanced course in their junior and senior years, provided they otherwise meet enrollment requirements.

Students who are unable to attend the six-week camp may also obtain basic course credit by completing a two-week summer program on campus and at Ft. Hamilton and West Point.

OBLIGATIONS

Upon graduation, students can elect to serve on full-time active duty for a three-year period in one of the various branches of the Army.

Based on the needs of the Army and the students’ desires, they may serve part-time in the Army Reserve or National Guard for a period of six years, thus still being able to pursue a civilian career.
Scholarship students incur a four-year active duty obligation. The professor of military science may designate outstanding cadets as distinguished military graduates. Students so designated may apply for a commission in the Regular Army of the United States.

**ARMY ROTC SCHOLARSHIPS**

Army ROTC offers four-, three-, and two-year scholarships. The four-year scholarships are awarded on a worldwide competitive basis to U.S. citizens who will be entering college as freshmen. The three- and two-year scholarships are awarded competitively to students who are enrolled in college and are academically aligned with an ROTC program.

Students who attend the basic camp of the two-year program may also compete for two-year scholarships.

The scholarships pay for tuition, textbooks, lab fees, plus a living allowance of up to $1,000 each year the scholarship is in effect.

**CREDITS TOWARD POLYTECHNIC DEGREES**

**BASIC COURSE**

Students enrolled in any of the basic course zero credit courses (MS 101, 102, 201, or 202) may substitute these courses for the Institute's physical education requirement.

The number of military science credits that are applicable toward Polytechnic degrees depends on the student's academic major and on which courses the student chooses to replace with ROTC courses.

**ADVANCED COURSE**

Up to six credits of the four two-credit courses (MS 301, 303, 401 or 403) may be substituted for free/technical electives as authorized by the individual departments.

**PROFESSIONAL ACTIVITIES**

ROTC offers a variety of social and professional activities:

- **Scabbard and Blade** is the advanced course national Military Honor Society, whose local chapter is active in service to the Military Science Department and the Institute.

- **The Pershing Rifles** promotes military ideals as exemplified by General John J. Pershing. The local chapter is active in tactical military training and in organizing a National Championship Drill Team.

- **The Society of American Military Engineers** promotes the national engineering potential for defense. The local student chapter is active in guest presentations in military and civilian engineering.

The National Association of Rigorous Training Units (Seppers) offers instruction in adventure training, such as mountaineering, rappelling, ranger, airborne and orienteering.

**HOW TO ENROLL**

Students should visit the Department of Military Science during the registration period so that the course can be integrated with normal registration procedures. Students interested in the two-year program should contact the department early in their sophomore year for application deadlines. If you have any questions concerning ROTC, telephone (212) 643-2105, or at the Farmingdale campus. (516) 454-5045.

**BASIC COURSES**

- **MS 101 Introduction to Military Science I** 2:0:0
  This course is an introduction to the ROTC program with balanced emphasis on academic and practical skills. Areas of study include the history and organization of ROTC, organization and purpose of the United States defense establishment, the role of key government organizations/officials in defense matters, first aid measures consisting of basic life-saving steps, and an introduction to physical fitness training and planning. The course also includes a four-hour laboratory which applies all skills taught. Extra credit field training exercises are available.

- **MS 201 Military Skills I** 2:1:0
  This course is designed to develop a sense of self-confidence in the student when exposed to living in a wilderness environment. Areas of study include theoretical and practical application of military mountaineering, tactics, and marksmanship. The mountaineering phase includes a Saturday field trip to West Point, New York. Tactics is taught at the small unit level, company and below. Basic marksmanship includes supervised firing of small bore rifle and pistol off campus at a local indoor range. Additionally, the course includes a four-hour laboratory which applies all military skills taught. Extra credit field training exercises are available. Prerequisite: MS 101 or permission of instructor.

- **MS 202 Military Skills II** 2:0:0
  This course is a continuation of MS 201. A large portion of this course is devoted to the study of leadership on an individual level. Areas of study include principles and traits of human behavior and psychology, command, discipline and decision-making. The remainder of the course is devoted to study and comparison of the weapons and equipment of the United States Army. The course also includes a four-hour laboratory which applies all military skills from previous classes. Extra credit field training exercises are available. Prerequisite: MS 201 or permission of the instructor.
ADVANCED COURSES

MS 301 Leadership and Management Techniques 2:0:2 or nc as arranged
This course explores leadership theory and techniques which are used by successful leaders and managers. The management skills of problem analysis, decision-making, planning, organizing, delegation and control are developed and applied within the context of realistic situations, using individual and small group practical exercises. Interpersonal skills needed to effectively utilize one's leadership and management skills in relations with others are developed and practiced.

MS 302 Leadership Skills I 3:0:0
Coursework is designed to develop the soldier skills, the physical capabilities, and the high motivational attitude which are required to meet the demands of today's modern army officer. The cadet will receive hands-on training on military equipment and will be part of a practical work experience emphasizing the role of group leader. Students work as a team, building individual confidence as well as team reliance. The course prepares the cadet for the leadership camp which follows this course during the summer months. Students are required to attend various field training exercises to reinforce classroom training. Prerequisite: permission of the department head.

MS 303 American Military History 2:0:2 or nc as arranged
Survey course stressing interrelationship between the American military establishment and American society: development of the American military system, the study of American wars: their causes, conduct and results; study of selected campaigns/battles; role of technology in the evolution of tactics and strategy.

MS 304 Leadership Skills II 3:0:0
Coursework is designed to develop the soldier skills, the physical capabilities, and the high motivational attitude which are required to meet the demands of today's modern Army officer. The cadet will receive hands-on training on military equipment and will be part of a practical work experience emphasizing the role as the group leader. Students work as a team, building individual confidence as well as team reliance. The course prepares the cadet for the leadership camp which follows this course during the summer months. Students are required to attend various field training exercises to reinforce classroom training. Prerequisite: MS 302 and permission of the department head.

Advanced Summer Camp nc
All candidates for commission through the ROTC program are required to successfully complete ROTC advanced camp, held at Fort Bragg, North Carolina. Stress placed on leadership and command responsibility, implemented by command rotation system that has each student assume varying positions of authority during the course of the normal military training program. Emphasis on weapons training and field operations. Camp lasts six weeks and normally is attended between the third and fourth years of college. Students receive travel expenses and pay while at camp. Prerequisites: junior standing, MS 302 and 304.

MS 401 Military Law, Ethics and Professionalism 2:0:2 or nc as arranged
This course introduces the student to the military justice system and its jurisdiction, military crimes, rights of individuals and the non-judicial and judicial options available to maintain discipline in the Army. Ethics and professionalism are discussed and their relationship to the military environment are explored. An ethical reasoning/decision-making process is developed and utilized in relation to case studies.

MS 402 Applied Leadership 2:1:0
Course intent is to round out the leadership skills of the cadet officers. Study areas are specifically geared toward providing skills necessary to function as cadet officers in areas such as formal classroom instruction, planning and conducting field training exercises, administration of the cadet battalion and exercising acquired leadership and managerial skills. The course is structured to permit formal instruction followed by a laboratory each week for practical application. Students are required to attend various field training exercises to reinforce classroom training. Prerequisite: advanced camp completion or permission of the department head.

MS 403 Pre-Commissioning Seminar 2:1:2 or nc as arranged
Topics designed to prepare senior cadets for commissioning as second lieutenants in the U.S. Army. Effective communication emphasizing military correspondence and staff writing; interpersonal relations; personnel management; career planning; Army logistics and administration; duties of the junior officer. Students are required to attend various field training exercises to reinforce classroom training. Prerequisite: MS IV cadet standing.

FACULTY

LTC Edward B. Weners, P.E., Professor and Head of the Department of Military Science
B.S., Northeastern University; M.S., Texas A&M University

MAJ Robert A. Lo Pinto, P.E., Assistant Professor of Military Science
B.S., Polytechnic Institute of New York; M.E., Manhattan College

MAJ Robert S. Graves, Assistant Professor of Military Science
B.S., M.A., Boston University

CPT Addison C.S. Masengill, Assistant Professor of Military Science
B.A., Davidson College

CPT George Oruska, Assistant Professor of Military Science
B.G.S., M. Nat. S., University of Idaho

SGM Thomas J. Myers, Chief Instructor

SFC Ricardo A. Anderson, Principal Drill Instructor

SSG Earl L. Kilgore, Instructor
A.A.S., North East State, Alabama Junior College

SP5 Fritz G. Wint, Instructor
NUCLEAR ENGINEERING

Nuclear engineering is the branch of the engineering profession concerned with the practical applications of nuclear energy, the energy emanating from the atomic nucleus. Today's nuclear engineers are in the forefront of efforts to solve the nation's mounting energy problems. By 1985 nearly 20 percent of the United States' electric power output will originate in nuclear power plants. At the present time, the nuclear industry is not getting new orders for power plants. However, experts expect the situation to reverse within ten years as the nation's present power plants age and the economy grows. New nuclear engineers are now required by utilities and the government.

Nuclear fusion, the energy source of the sun and hydrogen bombs, is under development by nuclear engineers and other technologists with the expectation that commercial nuclear fusion plants may become a reality in the early part of the next century.

Quite apart from the domain of nuclear power, nuclear engineers are involved with all problems related to nuclear radiation, its use and control. They are called upon to design facilities for radiation processing, the manufacture and utilization of radiopharmaceuticals and the numerous applications of radioactive substances in industry and commerce.

The Department of Nuclear Engineering offers programs of study leading to the bachelor of science, master of science, engineer and doctor of philosophy degrees.

UNDERGRADUATE PROGRAM

The undergraduate curriculum in nuclear engineering provides the students with a firm foundation in the fundamental sciences and engineering upon which the nuclear engineering profession is based. At the same time, the students receive sufficient training in nuclear engineering per se, either to embark directly upon an industrial career or to continue their education in graduate school. (See "Typical Course of Study" on the following page.)

GRADUATE PROGRAM

Requirements for the Master of Science Degree—A minimum of 36 units is required, including either the sequence NU 601-602 or NU 701-702 and the sequence NU 603-604, NU 605 and NU 607.

Requirements for the Degree of Engineer in Nuclear Engineering—A minimum of 36 units of work beyond the master's degree is required. The student must satisfactorily complete the sequences NU 701-702-703, NU 603-604, NU 605 and NU 607 or equivalents. In general, a project in nuclear engineering should also be completed. A maximum of 12 units, to be included within the overall unit requirements, may be devoted to the project. In special cases, where the student has previously completed work which would constitute a satisfactory project but which was accomplished in a non-academic setting, the project requirement may be waived.

Requirements for the Doctor of Philosophy Degree—The student must complete 90 units of graduate work, of which at least 24 units are devoted to completion of a thesis and at least 66 units to course work. The student must satisfactorily complete the sequences NU 701-702-703, NU 603-604, NU 605 and NU 607.

To be considered a doctoral candidate, a student must pass an examination, usually both written and oral. This examination will ordinarily precede starting of the thesis. On completion of the thesis, the student will be required to defend it satisfactorily at an oral examination.

While the specific course requirements for graduate degrees are minimal, every student should choose a program together with a departmental adviser. Students with differing interests and backgrounds may take substantially different programs in addition to the core courses.
Typical Course of Study for the Bachelor of Science Degree in Nuclear Engineering

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tr>
<td>First Semester</td>
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<td>No. Subject</td>
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<td>No. Subject</td>
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<tr>
<td>MA 101 Calculus I*</td>
<td>4 0 4</td>
<td>MA 102 Calculus II*</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3 0 3</td>
<td>PH 102 Introductory Physics II</td>
<td>3 ½ 1 ½ 4</td>
</tr>
<tr>
<td>CM 101 General Chemistry</td>
<td>2 ½ 0 2 ½</td>
<td>CM 102 General Chemistry II</td>
<td>2 ½ 0 2 ½</td>
</tr>
<tr>
<td>CM 111 General Chemistry Lab.</td>
<td>0 1 ½ 1 ½</td>
<td>CM 112 Gen. Chemistry Lab. II</td>
<td>0 1 ½ 1 ½</td>
</tr>
<tr>
<td>HU 101 College Composition*</td>
<td>3 0 3</td>
<td>HU 203 Intro. to Literature*</td>
<td>3 0 3</td>
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<tr>
<td>SS 104 Contemp. World Hist</td>
<td>3 0 3</td>
<td>PE 102 Physical Education</td>
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<td>PE 101 Physical Education</td>
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<td>17</td>
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</tbody>
</table>

Sophomore Year

| MA 104 Diff Equations* | 3 0 3 | MA 103 Calculus III* | 3 0 3 |
| MT 101 Mech. Behavior of Materials | 3 0 3 | Ph 102 Modern Physics | 2 ½ 1 ½ 4 |
| PH 103 Physics III | 2 ½ 1 ½ 3 | CE 102 Mech. of Materials | 3 0 3 |
| AM 116 Eng. Mech | 4 0 4 | EE 303 Intro. to Nuclear Eng. | 3 0 3 |
| AM 117 Fluids I | 3 0 3 | EE 374 Instrumentation Lab. | 0 3 1 |
| NU 103 Intro. to Nuclear Eng. | 3 0 3 | 0 1 ½ 1 ½ |
| PE 103 Physical Education | 0 2 0 | PE 104 Physical Education | 0 2 0 |
|                  | 16         |                  | 16         |

Junior Year

| MA 260 Vac. Anal./Par. Diff. Eq. | 4 0 4 | MA 358 Numerical Analysis | 3 0 3 |
| AM 201 Thermodynamics I | 3 0 3 | NU 302 Intro. to Nuclear Eng. | 3 0 3 |
| AM 231 Fluids I | 3 0 3 | NU 306 Radiation Protection | 3 0 3 |
| NU 301 Intro. to Nuclear Eng. | 3 0 3 | HU 106 Hist. /Soc. Sci.* | 3 0 3 |
| HU 107 Hist. /Soc. Sci.* | 3 0 3 | Free elective | 3 |
|                  | 18         | Technical elective | 3 |

Senior Year

| MA 201 Applied Analysis I | 3 0 3 | MA 202 Applied Analysis II | 3 0 3 |
| AM 203 Heat Transfer | 3 0 3 | NU 304 Nuclear Eng. Lab II | 2 ½ 1 ½ 3 |
| NU 302 Nuclear Eng. Lab. I | 2 ½ 1 ½ 3 | NU 308 Nuclear Eng. Design | 3 0 3 |
| NU 307 Licensing, Safety, Env. | 3 0 3 | NU 336 Atomic/Nuclear Physics II | 3 0 3 |
| NU 335 Atomic/Nuclear Physics | 3 0 3 | Technical elective | 3 |
| HU 108 Hist. /Soc. Sci.* | 3 0 3 | Free electives | 3 |
|                  | 18         |                  | 18         |

Total credits required for graduation: 135

*In the humanities and social sciences, the student must take HU 101 and either HU 200 and SS 104 or IS 140 and IS 141. Students who are placed in HU 103 must take at least one language from among French, German, and Russian. Students with a strong background in mathematics may wish to substitute the sequence MA 111-114 for MA 101-104.

The humanities and social sciences, the student must take HU 101 and either HU 200 and SS 104 or IS 140 and IS 141. Students who are placed in HU 103 must take at least one language from among French, German, and Russian.

*Students with a strong background in mathematics may wish to substitute the sequence MA 111-114 for MA 101-104.

**ROTC students should note that freshmen and sophomores may substitute zero credit military science courses for PE 101-104 (physical education). Juniors and seniors may substitute three of the following two credit courses, MS 131, 142, 143, 146, for six credits of technical electives.

At least 6 additional credits must be taken from outside the areas of modern languages. It is recommended that students intending to go on for the doctorate take at least one language from among French, German, and Russian.

Note that because of possible scheduling conflicts between courses, different departments may have different prerequisites. Students should consult their departmental advisors to avoid possible difficulties with prerequisites.
UNDERGRADUATE COURSES

NU 301 Introduction to Nuclear Engineering I 3:0:3
Introductory survey of nuclear engineering. Review of atomic and nuclear physics, interaction of radiation with matter, neutron chain reactions, nuclear reactor types. Prerequisite: PH 232 or equivalent.

NU 302 Introduction to Nuclear Engineering II 3:0:3
Continuation of NU 301. Elementary nuclear reactor design, reactor kinetics and control, heat removal from reactors. Prerequisite: NU 301.

NU 303 Nuclear Engineering Lab I 2½:1½:3
Study of radiation detection instruments, GM counters, proportional counters, ionization chambers, health physics instruments, scintillation spectrometry, activation analysis, cross-section and shielding measurements, macroscopic properties of reactor materials. Corequisite: NU 301.

NU 304 Nuclear Engineering Lab. II 2½:1½:3
Continuation of NU 303. Macroscopic properties of reactors, Fermi age, diffusion length, buckling, thermal utilization, resonance escape probability, delayed neutrons, criticality measurements, static and dynamic behavior of critical reactors. Prerequisite: NU 303.

NU 306 Principles of Radiation Protection 3:0:3

NU 307 Reactor Licensing, Safety and the Environment 3:0:3
Governmental authority and responsibility, reactor licensing, nuclear power plant safety, dispersion of effluents from nuclear facilities, radiation doses from nuclear power plants, reactor siting, reactor accidents, accident risk analysis, environmental radiation doses. Prerequisites: NU 302 and 306.

NU 308 Nuclear Engineering Design 3:0:3
A design course in which students address the full range of problems involved in the design of a practical nuclear facility. Each student must prepare and defend orally a design report on the facility. Prerequisite: NU 307.

NU 335-336 Atomic and Nuclear Physics I, II each 3:0:3
Introduction to electronic and nuclear structure of the atom. Relativity, wave mechanics, natural and artificial radioactivity, fission and cosmic rays. Fundamental experiments and postulates of wave and particle atomic physics. NU 335 prerequisite: PH 232. NU 336 prerequisite: NU 335.

NU 303 Nuclear Engineering Laboratory I 2½:1½:3
Study of radiation detection instruments, GM counters, proportional counters, ionization chambers, health physics instruments, scintillation spectrometry, activation analysis, cross-section and shielding measurements, macroscopic properties of reactor materials. Prerequisite: NU 301 or equivalent. Lab fee required.

NU 304 Nuclear Engineering Laboratory II 2½:1½:3
Continuation of NU 303. Macroscopic properties of reactors, Fermi age, diffusion length, buckling, thermal utilization, resonance escape probability, delayed neutrons, criticality measurements, static and dynamic behavior of critical reactors. Prerequisite: NU 303. Lab fee required.

NU 306 Principles of Radiation Protection 3:0:3
Fundamentals of health physics and radiation protection. Interaction of ionizing radiation with matter, biological effects of radiation, dosimetry, radiation shielding, radiation codes. Prerequisite: NU 301 or equivalent.

NU 307 Reactor Licensing, Safety and the Environment 3:0:3
Governmental authority and responsibility, reactor licensing, nuclear power plant safety, dispersion of effluents from nuclear facilities, radiation doses from nuclear power plants, reactor siting, reactor accidents, accident risk analysis, environmental radiation doses. Prerequisites: NU 302 and 306.

NU 308 Nuclear Engineering Design 3:0:3
A design course in which students address the full range of problems involved in the design of a practical nuclear facility. Each student must prepare and defend orally a design report on the facility. Prerequisite: NU 307.

NU 335-336 Atomic and Nuclear Physics I, II each 3:0:3
Introduction to electronic and nuclear structure of the atom. Relativity, wave mechanics, natural and artificial radioactivity, fission and cosmic rays. Fundamental experiments and postulates of wave and particle atomic physics. NU 335 prerequisite: PH 232. NU 336 prerequisite: NU 335.

GRADUATE COURSES

NU 601 Introduction to Nuclear Engineering I 3:0:3
Introductory survey of nuclear engineering. Review of atomic and nuclear physics, interaction of radiation with matter, neutron chain reactions, nuclear reactor types. Prerequisite: PH 232 or equivalent.

NU 602 Introduction to Nuclear Engineering II 3:0:3
Continuation of NU 601. Elementary nuclear reactor design, reactor kinetics and control, heat removal from reactors. Prerequisite: NU 601.

NU 603 Nuclear Engineering Laboratory I 2½:1½:3
Study of radiation detection instruments, GM counters, proportional counters, ionization chambers, health physics instruments, scintillation spectrometry, activation analysis, cross-section and shielding measurements, macroscopic properties of reactor materials. Prerequisite: NU 601 or equivalent. Lab fee required.

NU 604 Nuclear Engineering Laboratory II 2½:1½:3
Continuation of NU 603. Macroscopic properties of reactors, Fermi age, diffusion length, buckling, thermal utilization, resonance escape probability, delayed neutrons, criticality measurements, static and dynamic behavior of critical reactors. Prerequisite: NU 603. Lab fee required.

NU 606 Principles of Radiation Protection 3:0:3
Fundamentals of health physics and radiation protection. Interaction of ionizing radiation with matter, biological effects of radiation, dosimetry, radiation shielding, radiation codes. Prerequisite: NU 601 or equivalent.

NU 607 Reactor Licensing, Safety and the Environment 3:0:3
Governmental authority and responsibility, reactor licensing, nuclear power plant safety, dispersion of effluents from nuclear facilities, radiation doses from nuclear power plants, reactor siting, reactor accidents, accident risk analysis, environmental radiation doses. Prerequisites: NU 602 and 606.

NU 619 Introduction to Thermonuclear Power 3:0:3
Survey of problems associated with attaining controlled thermonuclear power. Fusion reactions, thermonuclear reaction rates, plasma physics, thermonuclear reactions, methods of plasma containment, energy extraction from plasmas. Also listed under EL 657.

NU 701 Nuclear Reactor Theory I* 3:0:3
Intermediate course in nuclear reactor theory. Review of neutron interactions, flux, current and neutron diffusion. Prerequisite: NU 602 or equivalent.

NU 702 Nuclear Reactor Theory II* 3:0:3
Continuation of NU 701. Neutron slowing down with and without absorption and fission, Fermi age and group theories of critical systems. Prerequisite: NU 701.

NU 703 Nuclear Reactor Theory III* 3:0:3
Continuation of NU 702. Heterogeneous reactors, reactor kinetics, temperature coefficients, fission product poisoning, reactor controls, perturbation theory. Prerequisite: NU 702.

NU 705-706 Advanced Nuclear Engineering Laboratory I, II* each 2½:1½:3
Selected advanced experiments chosen to reflect the interests of the students, subject to the availability of necessary laboratory equipment. Prerequisite: NU 604. Lab fee required.

NU 712 Radiation Shielding* 3:0:3
Theory and practice of neutron and gamma ray shielding. Prerequisite: NU 606.

NU 715 Heat Transfer 2½:0:3

Also listed under AM 715.
NU 716 Reactor Heat Transfer 2½:0:3
Study of heat transfer problems and solution techniques associated with various test, power and propulsion nuclear reactors including BWR, PWR, LMFR and HTGR. Core geometries and primary loop components. Introduction to flow boiling phenomena, liquid metal heat transfer, combined convection and radiation gas flow. Behavior during loss of coolant accidents and emergency core cooling systems. Prerequisite: NU 715 or equivalent.
Also listed under AM 716

NU 721 Economics of Nuclear Power 3:0:3
Economic considerations in design of stationary nuclear power plants. Prerequisite: NU 652.

NU 726 Metallurgy of Nuclear Reactor Materials* 3:0:3
Study of material requirements for basic parts of nuclear reactors. Metallurgy of fuels, moderator, control and construction materials. Description of handling and fabricating techniques. Prerequisite: advisor’s approval.
Also listed under MT 725

NU 731 Nuclear Chemical Engineering* 3:0:3
Application of chemical engineering principles to processing of nuclear engineering materials. Fuel cycles of nuclear reactors, chemistry of uranium, plutonium, fission products, theory of isotope separation processes. Prerequisite: NU 652.

NU 741 Probabilistic Risk Assessment 2½:0:3
Probabilistic risk assessment methods and applications associated with nuclear reactors. Includes the following topics: probability theory and statistics; Boolean algebra and fault tree analysis; time-dependent reliability; Markov modeling; extreme value theory; common mode failure analysis; event trees and accident analysis; physical processes associated with core meltdown, offsite consequence analysis. Applications to operating commercial reactors and to the design of advanced reactors will be given. Prerequisites: NU 801-802 or equivalent

NU 801 Radiation Transport Theory I* 3:0:3
Linear transport equation; applications of conservation principles, geometrical attenuation; solution methods with application to classical albedo, mine and criticality problems. Prerequisite: instructor’s permission.

NU 802 Radiation Transport Theory II* 3:0:3
Continuation of NU 801. Further discussion of solution techniques, diffusion boundary conditions, energy-dependent neutrons, radiative transfer. Prerequisite: NU 801

NU 811 Control of Nuclear Reactor Plants I* 3:0:3
Introduction to control systems and nuclear reactor dynamics. State space representation of dynamical systems, input-output relations, Laplace transform, state transition function, transfer function. Analysis of linear systems, stability of linear systems. Derivation of reactor dynamics equations, feedback reactivity, linear reactor dynamics. Introduction to nonlinear dynamical systems. Lyapunov function, stability of nonlinear systems. Prerequisite: NU 703

NU 812 Control of Nuclear Reactor Plants II* 3:0:3

NU 902-903 Seminar in Nuclear Engineering nc
Recent developments in the field of nuclear engineering through lectures given by scientists and engineers from industry, research and educational institutions, and by staff members and qualified graduate students.

NU 911-914 Projects in Nuclear Engineering 3:0:3
Project course of advanced nature, conducted by assigning individual investigations to be performed by student under supervision of staff member. Consists of theoretical and experimental engineering of interest to student.

NU 927 Energy Policy Issues 2½:0:3
See Energy Program for details.

NU 928 Energy Resource Distribution and Conversion Technology 2½:0:3
See Energy Program for details.

NU 935 Engineering Projects Related to Public Administration each 3 units
See Section on Interinstitutional Agreements, Cooperative Program with NYU-Public Administration.

NU 951-962 Thesis for Degree of Master of Science each 3 units
Independent investigation of problem in nuclear engineering. Acceptance of student by faculty advisor required before registration. Registration fee, any part—3-unit charge. Prerequisite: degree status.

NU 971-972 Project for Degree of Engineer each 3 units
Independent project in nuclear engineering. Acceptance of student by faculty advisor required before registration. Registration fee, any part—3-unit charge. Prerequisite: candidacy for engineer degree.

NU 981-988 Thesis for Degree of Doctor of Philosophy each 3 units
Original investigation in some aspect of nuclear engineering or science. Candidate required to defend thesis at oral examination. Acceptance of student by faculty advisor required before registration. Registration fee, any part—3-unit charge. Prerequisite: candidacy for Ph.D. degree.

FACULTY

Robert F. Benenati, Head, Department of Chemical Engineering and Nuclear Engineering
B.S., M.Ch.E., Ph.D., Polytechnic Institute of Brooklyn

Raphael Aronson, Professor of Nuclear Engineering and Physics
B.S., University of Minnesota; M.A., Ph.D., Harvard University
Transport theory

KunMo Chung, Research Professor of Nuclear Engineering
B.S., Seoul National University (Korea); Ph.D., Michigan State University
Thermonuclear power, international nuclear power development

Walter Kiszenick, Associate Professor of Physics and Nuclear Engineering
B.S., Brooklyn College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Electron microscopy, x-ray diffraction, experimental reactor physics
Richard S. Thorsen, Associate Professor of Mechanical Aerospace and Nuclear Engineering. B.M.E., CCNY; M.M.E., Ph.D., New York University
Heat transfer, energy conversion, nuclear reactor safety

ADJUNCT FACULTY—BROOKLYN CAMPUS

Howard S. Cohen, Adjunct Professor of Nuclear Engineering
B.S., New York University; M.S.N.U.E., Penn State University

Robert W. Kupp, Adjunct Professor of Nuclear Engineering
B.S., Wayne State University

Saturnino C. Mairal, Adjunct Instructor of Nuclear Engineering
B.S., University of Bilbao, Spain; M.S., Polytechnic Institute of New York

S. Moizul Matin, Adjunct Professor of Nuclear Engineering
B.S., Karachi University, Pakistan; A.M., Ph.D., Columbia University

David C. Purdy, Adjunct Professor of Nuclear Engineering
B.S., Webb Institute of Naval Architecture; Oak Ridge School of Reactor Technology

ADJUNCT FACULTY—
BROOKHAVEN NATIONAL LABORATORY

Robert A. Bari, Adjunct Professor of Nuclear Engineering
A.B., Rutgers—The State University; Ph.D., Brandeis University

Ralph J. Cerbone, Adjunct Professor of Nuclear Engineering
B.S., Boston College; M.S., Ph.D., Rensselaer Polytechnic Institute

David J. Diamond, Adjunct Professor of Nuclear Engineering
B.E.P., Cornell University; M.S., University of Arizona; Ph.D., Massachusetts Institute of Technology

Ady Hershcovitch, Adjunct Professor of Nuclear Engineering
B.S., New York University; S.M., Sc.D., Massachusetts Institute of Technology

Frank B. Hill, Adjunct Professor of Nuclear Engineering
B.Ch.E., Catholic University of America; Ph.D., Princeton University

Raymond Karol, Adjunct Professor of Nuclear Engineering
B.S., Rutgers University, M.S., Polytechnic Institute of New York

Melvin M. Levine, Adjunct Professor of Nuclear Engineering
B.S., Ph.D., Massachusetts Institute of Technology

Hans Ludewig, Adjunct Professor of Nuclear Engineering
B.S., M.S., University of Natal; M.S., Ph.D., California Institute of Technology

Peter M. Meier, Adjunct Professor of Nuclear Engineering
M.S., Ph.D., University of Massachusetts

David C. Rorer, Adjunct Professor of Nuclear Engineering
B.S., Massachusetts Institute of Technology; M.S., University of Illinois; Ph.D., Duke University

John R. Weeks, Adjunct Professor of Nuclear Engineering and Metallurgy
Met.E., Colorado School of Mines; M.S., Ph.D., University of Utah

Wolfgang Wulff, Adjunct Professor of Nuclear Engineering
B.S.M.E., Institute of Technology Winterthur, Switzerland; M.S., Ph.D., Illinois Institute of Technology

William G. Shiffmacher, Adjunct Lecturer in Nuclear Engineering
B.E.E., Manhattan College, M.S., Long Island University

Frank J. Vitale, Adjunct Lecturer in Nuclear Engineering
B.E.E., Polytechnic Institute of Brooklyn; M.S., C.W. Post College
OPERATIONS MANAGEMENT

Operations management approaches specific production operations so as to maximize the cost leverage of an organization. Throughout industry there is a growing perception that productivity is the key to successful world-market competition and that too few managers have the pertinent skills. Today’s operations managers require skills reaching beyond those just based on industrial engineering. The new operations manager must understand accounting, psychology, productivity and EDP, rather than just computing.

The role of the operations manager reaches beyond that of production management. The operations manager is being integrated as part of the corporate management system rather than being isolated in a factory. In addition to purely industrial settings, the production and management techniques are used in health care organizations, financial institutions, insurance companies, and in many other service sectors, such as transportation, distribution, hotel, maintenance and retailing. Students would select this program to take advantage of the current demand for jobs in operations management as well as to avoid choosing between MBA or industrial engineering degrees.

The course work in operations management covers the viewpoints and tools drawn largely from the fields of management and industrial engineering. These subjects include statistics, computers, work design and measurement, management process, accounting, productivity management, and statistical quality control, plus other subjects chosen by the student through electives.

This is a graduate program jointly administered by the Division of Engineering and the Division of Management. One director of the operations management program represents the management division of Polytechnic. The other represents industrial engineering. Operations management draws its courses from several disciplines within the Institute. This multidisciplinary program prepares students to manage technological, social and economic developments that affect the means and methods of satisfying human needs for products and services.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

To be eligible for admission to this program, the applicant must hold a baccalaurate degree or its equivalent from an accredited institution in one of the following areas: engineering (other than industrial), physical sciences, liberal arts, business or public administration, or social sciences. Students are expected to have an adequate background in mathematics. Students lacking such background may be admitted, subject to taking courses making up the deficiency. Such courses are in addition to other normal degree requirements.

<table>
<thead>
<tr>
<th>Units</th>
<th>A. Basic required courses*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MA 551 Applied Statistics I (Data Analysis)</td>
</tr>
<tr>
<td></td>
<td>MG 602 Computers in Management</td>
</tr>
<tr>
<td></td>
<td>IE 601 Introduction to Digital Computing</td>
</tr>
<tr>
<td></td>
<td>IE 600 Engineering Economic Analysis</td>
</tr>
<tr>
<td></td>
<td>IE 606 Work Design and Measurement</td>
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<tr>
<td></td>
<td>MG 600 Management Process</td>
</tr>
<tr>
<td></td>
<td>MG 604 Managerial Accounting</td>
</tr>
<tr>
<td></td>
<td>HU 605 Report Writing</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>B. Required courses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MG 601 Organizational Behavior</td>
</tr>
<tr>
<td></td>
<td>MG 630** Operations Management</td>
</tr>
<tr>
<td></td>
<td>MG 810 Project Planning and Control</td>
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<td></td>
<td>MG 645 Productivity Management</td>
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<tr>
<td></td>
<td>IE 611 Statistical Quality Control</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>C. Major electives (Choose Three)***</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IE 913 Selected Topics in Operations Management</td>
</tr>
<tr>
<td></td>
<td>IE 776 Material Requirements Planning</td>
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<td></td>
<td>IE 777 Manufacturing Improvement Curves</td>
</tr>
<tr>
<td></td>
<td>MG 507 Marketing Management</td>
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<td></td>
<td>MG 850 Cost Systems</td>
</tr>
<tr>
<td></td>
<td>IE 765 Human Factors in Engineering Design</td>
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<tr>
<td></td>
<td>IE 775 Industrial Safety Engineering</td>
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<tr>
<td></td>
<td>MG 762 Managerial Economics</td>
</tr>
<tr>
<td></td>
<td>MG 763 National Economic Models and Forecasting</td>
</tr>
<tr>
<td></td>
<td>SS 920 Proseminar in Psychology</td>
</tr>
<tr>
<td></td>
<td>SS 926 Environmental Psychology</td>
</tr>
<tr>
<td></td>
<td>MG 624 Organization Development</td>
</tr>
<tr>
<td></td>
<td>Total: 36</td>
</tr>
</tbody>
</table>

*All group A courses are required unless they are specifically waived by the adviser because the student either (a) has taken equivalent undergraduate or graduate courses, or (b) passes a validation examination for these courses. Up to four group A courses actually taken may be credited toward the degree requirements, if more than four must be taken, the degree requirements will be increased accordingly.

**May substitute IE 627 or IE 618

***Only one of each bracketed set of courses will be counted in the group in which it is listed.
COURSES

OM 976-977 Readings in Operations Management each 3 units
Directed individual study or supervised readings in advanced areas of operations management. Prerequisite: permission of adviser.

OM 997 Thesis in Operations Management each 3 units
Original investigation in topic chosen by student. Conferences and progress reports required during work and final written report required. Registration and degree credit beyond first six units require separate approval. Prerequisites: degree status and approval of supervising adviser.

FACULTY

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management, Co-Director of Operations Management Program
David A. Schrier, Assistant Professor of Management, Co-Director of Operations Management Program
Norbert Hauser, Professor of Industrial Engineering and Management Science
John H. K. Kao, Professor of Industrial Engineering B.S., National Central University (China), M.S., D.Eng.Sc., Columbia University
Anne Eisenberg, Associate Professor of Humanities and Communications
Seymour Kaplan, Associate Professor of Operations Research and Management Science B.S., Newark College of Engineering, M.S., Ph.D., New York University
Richard E. Wener, Visiting Assistant Professor of Psychology
Vincent K. Omachonu, Instructor of Industrial Engineering and Operations Management

ADJUNCT FACULTY

Byron L. David, Adjunct Associate Professor
Chaim Steinberger, Adjunct Instructor
The Department of Industrial Engineering and Operations Research offers programs in the area of operations research at the bachelor's, master's and doctoral levels.

The field of operations research is concerned with the development and application of advanced analytical techniques to the operation of complex systems and the optimal allocation of resources. The last few decades have witnessed an increasing use of mathematical models in nearly all fields of endeavor. There is a need for trained professionals who can play important roles in the development of quantitative models and solution techniques for a broad array of challenging problems.

Operations researchers address themselves to such problems as production, distribution and marketing, allocation of urban resources, industrial and government operation and economic theory. They deal with analysis, design and utilization of modern, large-scale systems ranging from completely automated processing plants through urban systems—transportation, justice and health care, for example—to managerial systems composed solely of human beings. They concern themselves with those areas in which the systems approach, engineering knowledge, and analytical techniques are applied directly to the most urgent problems of society.

Operations research is a rapidly developing professional field with opportunities in many diverse areas. For example, practitioners are called on to:
- Analyze and plan production schedules and inventories
- Devise ways of maximizing the effectiveness of hospitals and other health care facilities
- Study the feasibility of equipment replacement
- Evaluate proposed traffic control procedures
- Locate new plants and design their physical layout
- Measure the effectiveness of advertising and marketing policies
- Evaluate effectiveness of urban solid waste collection and removal systems
- Develop computer simulations of man-machine systems
- Study the effects of feedback and automation in society and industry

Operations researchers concern themselves with systems in which the mission is imprecisely specified, in which limited resources are available, or where there is great variability in input and output demands. They are involved in decision-making in the face of incomplete information and conflicting objectives—objectives that frequently cannot be adequately defined, that are subjective and that are difficult to quantify. They seek to allocate limited resources in an optimal manner. A unifying theme focusing this body of knowledge and methods into a coherent entity is the system point of view. The search for similarity among concepts, laws and models of different disciplines, the emphasis on the adaptation, integration and exploitation of existing techniques in areas other than their fields of origin, and above all, a unique point of view dealing with relationships rather than with components—these characterize the orientation.

UNDERGRADUATE PROGRAM

The undergraduate program leads to the degree of bachelor of science in operations research. The program is built on the essential scientific and mathematical foundations underlying its field.

The undergraduate program requires 128 credit hours of work, including mathematics, chemistry, physics, humanities, social science, required departmental courses, and technical and free electives. The humanities, technical and free electives permit an extremely flexible program of study in which the student has the opportunity to pursue individual interests that build on the core requirements. Some possible elective sequences are listed after the curricula; these are mere suggestions, not required sequences of study.

The student wishing to enter this field should normally prepare to continue studies beyond the bachelor's level. Accordingly, undergraduate training places heavy emphasis on mathematics and the basic physical and social sciences necessary for graduate study in this area.
COMPUTER SCIENCE OPTION

Operations research is affected by the availability and use of computers, perhaps even more so than most other scientific and engineering disciplines. Hence the department, in cooperation with the Computer Science Division, has developed a computer science option in the operations research program. This option comprises virtually a dual major in operations research and computer science. The two fields complement each other most advantageously and, therefore, will give the student a particularly effective preparation for a professional career.

Graduate Courses may be taken as electives by qualified juniors and seniors with at least a B average, who obtain their adviser's approval. If the total number of credits exceeds those required for the bachelor's degree, these graduate credits may be credited toward a graduate degree in accordance with current policy.

TRANSFER STUDENTS

Transfer students who have completed two years of study at a college of liberal arts and science or a community college may ordinarily complete the requirements for the bachelor's degree in two additional years of study. Assuming that he/she has completed 64 credits equivalent to MA 101-104, MA 153, MA 223, MA 224, MA 555, CM 101, CM 102, CM 111, CM 112, CS 100, PH 101, PH 102, PH 103, HU 101, HU 200, SS 104, SS 251, SS 252, plus 17 credits of acceptable electives, the student can complete the requirements shown.

EVENING STUDY

All courses for the operations research program are available in the evening or late afternoon for the convenience of part-time students. A part-time student usually can finish the program in eight years, without summer work, by averaging eight credits per semester. However, students can change the pace readily to suit their educational needs, provided they do not violate prerequisites and Institute time limits.

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See footnotes on following page.
Typical Course of Study for the Degree of Bachelor of Science in Operations Research

A typical program sequence covering eight semesters is shown below. Students may rearrange courses and increase or decrease load per semester to suit their educational needs, provided prerequisites are not violated. In particular, the actual number of electives and total credits in any given semester will vary by one or two credits because most electives are three credits.

### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.  Subject</td>
<td>Cl. Lab. Cr.</td>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>CS 100 Intro. to Computer Progrmg(^1)</td>
<td>2 0 2</td>
<td>HU 200 Intro to Literature(^1)</td>
<td>3 0 3</td>
</tr>
<tr>
<td>HU 101 College Composition</td>
<td>3 0 3</td>
<td>MA 102 Calculus II(^1)</td>
<td>4 0 4</td>
</tr>
<tr>
<td>MA 101 Calculus I(^1)</td>
<td>4 0 4</td>
<td>PH 102 Introductory Physics II</td>
<td>3 1/2 1 1/2 4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3 0 3</td>
<td>SS 252 Macro-Economics</td>
<td>3 0 3</td>
</tr>
<tr>
<td>SS 251 Micro-Economics</td>
<td>3 0 3</td>
<td>PE 102 Physical Education(^2)</td>
<td>0 2 0</td>
</tr>
<tr>
<td>PE 101 Physical Education (^3)</td>
<td>0 2 0</td>
<td>Electives(^2)</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
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</tbody>
</table>

### Sophomore Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 101 General Chemistry I</td>
<td>2 1/2 0 2 1/2</td>
<td>CM 102 General Chemistry II</td>
<td>2 1/2 0 2 1/2</td>
</tr>
<tr>
<td>CM 111 General Chemistry Lab. I</td>
<td>0 1/2 1/2</td>
<td>CM 112 General Chemistry Lab. II</td>
<td>0 1/2 1/2</td>
</tr>
<tr>
<td>IE 254 Intro. to Industrial Engrg.</td>
<td>3 0 3</td>
<td>IE 253 Calculus III(^1)</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 104 Appl. Differential Eqns.(^1)</td>
<td>3 0 3</td>
<td>MA 153 Elem. of Linear Algebra</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH 103 Introductory Physics III</td>
<td>2 1/2 1 1/2 3</td>
<td>SS 104 Contemp. World Hist.(^1)</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE 103 Physical Education III(^3)</td>
<td>0 2 0</td>
<td>PE 104 Physical Education IV(^3)</td>
<td>0 2 0</td>
</tr>
<tr>
<td>Electives(^2)</td>
<td>4</td>
<td>Electives(^2)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

### Junior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 327 Operations Research I</td>
<td>3 0 3</td>
<td>IE 300 Engineering Economy</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 223 Intro to Probability</td>
<td>3 0 3</td>
<td>IE 328 Operations Research II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>Electives(^2)</td>
<td>10</td>
<td>IE 380 System Simulation</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td><strong>16</strong></td>
<td>MA 224 Intro to Math. Statistics</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electives(^2)</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 319 Product Planng. &amp; Control</td>
<td>3 0 3</td>
<td>IE 346 Oper. Des. of Public Syst.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 555 Design of Experiments</td>
<td>3 0 3</td>
<td>Electives(^2)</td>
<td>0 0 13</td>
</tr>
<tr>
<td>Electives(^2)</td>
<td>10</td>
<td></td>
<td><strong>Total</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

Total credits required for graduation: 128

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1 Students may substitute IS 140, IS 141 for HU 200. Students with strong mathematical backgrounds may substitute MA 111, MA 114 for MA 101-MA 104. Students may substitute CS 111 for CS 100, the extra credit may be counted as technical elective. The advisor may approve the substitution of another statistics in place of MA 555.

2 Electives are to be distributed as follows: 12 credits of courses in operations research and industrial engineering.

3 12 credits of technical electives: engineering or science.

4 15 credits of humanities and social science.

5 9 credits of free electives; normally any course that does not duplicate others.

6 ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101-104 (physical education). Juniors and seniors may substitute three of the following two credit courses: MS 301, 303, 401 or 403, for six credits of technical electives.
## Typical Course of Study for Transfer Students

### Junior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>IE 254</td>
<td>Industrial Management</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 327</td>
<td>Operations Research I</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 223</td>
<td>Intro. to Probability</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Electives*</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
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</table>

### Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>IE 319</td>
<td>Product Planning &amp; Control</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 555</td>
<td>Design of Experiments I</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Electives*</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

### Second Semester

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>IE 300</td>
<td>Engineering Economy</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 328</td>
<td>Operations Research II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 380</td>
<td>System Simulation</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 153</td>
<td>Elements of Lin. Algebra</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 224</td>
<td>Intro. to Math Statistics</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 346</td>
<td>Oper. Design of Public Syst.</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Electives*</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
</tr>
</tbody>
</table>

**Total credits required for graduation: 128**

### Requirements for the Degree of Bachelor of Science in Operations Research (Computer Science Option)

<table>
<thead>
<tr>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mathematics</strong></td>
</tr>
</tbody>
</table>

**Industrial Engg** | IE 254, IE 300, IE 314, IE 319, IE 327, IE 328, IE 346, IE 380 | 24 |

**Science** | CS 111, CS 203, CS 204, CS 205, CS 206, CS 236, CS 237, CS 238, CS 297, CS 299 | 28 |

**Humanities** | HU 101, HU 110, HU 200*, SS 104*, SS 251, SS 252 | 18 |

**Electives** | 12 credits Humanities*, Social Science, 7 credits free | 19 |

**Total** | 128 |

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*See notes under typical course of study, preceding page*
Typical Course of Study for the Degree of Bachelor of Science in Operations Research (Computer Science Option)

A typical program covering eight semesters is shown below. Students may rearrange courses and increase or decrease load per semester to suit their educational needs, provided prerequisites are not violated. In particular, the actual number of electives and total credits in any given semester will vary by one or two credits because most electives are three credits.

<table>
<thead>
<tr>
<th>Freshman Year</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<tbody>
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<td>Second Semester</td>
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<td>No. Subject</td>
<td>Cl. Lab Cr</td>
<td>No. Subject</td>
<td>Cl. Lab Cr</td>
</tr>
<tr>
<td>CS 111 C Progrm. I</td>
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<td>CS 236 Switch Circ. &amp; Dig. Sys I</td>
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<th>Hours/Week</th>
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<td>CS 238 Computer Systems</td>
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</tr>
<tr>
<td>CS 237 Intro. to Comput. Arch</td>
<td>3 0 3</td>
<td>CS 299 Computer Lab II</td>
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</tr>
<tr>
<td>IE 327 Operation Research I</td>
<td>3 0 3</td>
<td>IE 314 Modeling of Soc. Sys</td>
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<tr>
<td>MA 223 Intro. to Probability</td>
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<td>IE 319 Prodctn. Planning. &amp; Control</td>
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<tr>
<td>SS 251 Microeconomics</td>
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<tr>
<td>CS 206 Compilers</td>
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<tr>
<td>CS 297 Computer Lab I</td>
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<td>IE 328 Operations Res.</td>
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<tr>
<td>IE 380 System Simulation</td>
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<tr>
<td>MA 224 Intro. to Math. Statistics</td>
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<tr>
<td>SS 252 Macroeconomics</td>
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</table>

|               | 15         |

Total credits required for graduation: 128

Students may substitute IS 140, IS 141 for HU 200, SS 104. Students with strong mathematical backgrounds may substitute MA 111, MA 114 for MA 101-MA 104.

ROTC students should note that freshmen and sophomores may substitute zero-credit military science courses for PE 101-104 (physical education); juniors and seniors may substitute three of the following two-credit courses: MS 301, 303, 401 or 403 for six credits of technical electives.
**SUGGESTED ELECTIVE SEQUENCES**

Students often seek guidance in using the permitted electives to develop a meaningful sequence for concentration. Some suggested groupings are shown below from which the student may select electives. Courses numbered 600 or above are graduate courses requiring a B or better average and the advisor's special permission. Since these suggestions are addressed to both industrial engineering and operations research students, some of the electives may duplicate required courses. These are merely suggestions, not required sequences of study.

<table>
<thead>
<tr>
<th>Behavioral Science</th>
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<tr>
<td>SS 175 Introduction to Sociology</td>
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<tr>
<td>SS 185 Anthropology: Physical</td>
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</tr>
<tr>
<td>SS 189 Intro. to Psychology</td>
<td>3</td>
</tr>
<tr>
<td>SS 191 Social Psychology</td>
<td>3</td>
</tr>
<tr>
<td>SS 192 Experimental Psychology I</td>
<td>3</td>
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<tr>
<td>SS 193 Experimental Psychology II</td>
<td>3</td>
</tr>
<tr>
<td>SS 198 Psychology of Human Development</td>
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<tr>
<td>SS 199 Organizational Behavior</td>
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<tr>
<th>Bioengineering</th>
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<tr>
<td>BE 201 Systems Approach to Biomedicine I</td>
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</tr>
<tr>
<td>BE 202 Systems Approach to Biomedicine II</td>
<td>2</td>
</tr>
<tr>
<td>CM 122 Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CM 164 Phys. Chem. of Living Systems</td>
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</tr>
<tr>
<td>LS 105 General Biology I</td>
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<td>LS 106 General Biology II</td>
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<td>LS 115 General Biology Lab I</td>
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<tr>
<th>Computer Science</th>
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<tbody>
<tr>
<td>CS 203 Computer Programming II</td>
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<tr>
<td>CS 204 Intro. to Data Structures</td>
<td>3</td>
</tr>
<tr>
<td>CS 205 Assem. &amp; Mach. Lang. Prog.</td>
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</tr>
<tr>
<td>CS 206 Compilers</td>
<td>3</td>
</tr>
<tr>
<td>CS 236 Switch. Circuits &amp; Digital Syst.</td>
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</tr>
<tr>
<td>CS 237 Intro. to Comp. Architecture</td>
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</tr>
<tr>
<td>CS 238 Computer Systems</td>
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</tr>
<tr>
<td>CS 297 Computer Laboratory I</td>
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<td>CS 299 Computer Laboratory II</td>
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<table>
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<tr>
<th>Control Systems</th>
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<tbody>
<tr>
<td>EE 101 Electrical Systems I</td>
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<tr>
<td>EE 102 Electrical Systems II</td>
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</tr>
<tr>
<td>EE 103 Electrical Systems III</td>
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<td>EE 104 Feedback Syst. Theory w. Appl.</td>
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<tr>
<td>EE 107 Control System Design</td>
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<tr>
<td>EE 111 Solid-State Devices &amp; Circuits I</td>
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<td>EE 141 Signal Processing</td>
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<tr>
<td>SS 255 The Contemp. Amer. Economy</td>
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<td>SS 257 History of Economic Thought</td>
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<tr>
<td>SS 259 Comparative Economic Systems</td>
<td>3</td>
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<td>SS 259 Economic Development</td>
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<td>SS 263 Labor Economics</td>
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<tr>
<td>SS 264 Urban Economics</td>
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<td>SS 265 Money and Banking</td>
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<td>MG 300 Management Process</td>
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<td>MG 304 Accounting Fundamentals</td>
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<tr>
<td>MG 612 Human Resources Management</td>
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<td>MG 664 Legal Environment of Business</td>
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<tr>
<td>MA 153 Elements of Linear Algebra</td>
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<tr>
<td>MA 201 Applied Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>MA 202 Applied Analysis II</td>
<td>3</td>
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<tr>
<td>MA 217 Complex Variables</td>
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<td>MA 280 Vector Anal. &amp; Part. Diff. Equa.</td>
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<td>MA 356 Intro. Numerical Analysis</td>
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<tr>
<td>MA 153 Elements of Linear Algebra</td>
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<tr>
<td>IE 618 Inventory Models</td>
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<tr>
<td>IE 631 Linear Programming</td>
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<tr>
<td>IE 632 Nonlinear Programming</td>
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<td>IE 650 Queuing Systems</td>
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<tr>
<td>IE 311 Statistical Quality Control</td>
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<tr>
<td>MA 232 Statistical Methods II</td>
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<tr>
<td>MA 235 Applied Probability</td>
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<tr>
<td>MA 254 Applied Decision Theory</td>
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<tr>
<td>MA 558 Correl. &amp; Multivar. Mod.</td>
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<tr>
<td>MA 637 Sampling</td>
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<tr>
<td>IE 852 Regression &amp; Anal. of Variance</td>
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<tr>
<td>IE 853 Design of Experiments</td>
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<tr>
<td>TR 360 Traffic Planing &amp; Oper.</td>
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<tr>
<td>TR 361 Transportation Models</td>
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<tr>
<td>TR 362 Public Transit Tech. &amp; Oper.</td>
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<tr>
<td>TR 753 Mgt. of Transp. &amp; Distri. Ops.</td>
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<tr>
<td>TR 754 Logistics Analysis</td>
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<tr>
<td>IE 346 Oper. Des. of Urban Systems</td>
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<tr>
<td>LS 140 Environmental Biology</td>
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<tr>
<td>SS 180 Sociology of Urbanization</td>
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<td>SS 182 Man and the Environment</td>
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<td>SS 190 Environmental Psychology</td>
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<tr>
<td>SS 264 Urban Economics</td>
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</tr>
<tr>
<td>TR 630 Urban Planning Principles</td>
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**GRADUATE STUDY**

The department offers master of science and doctor of philosophy degree programs in the area of operations research.

This curriculum encompasses the related fields of operations research and management science. It is directed toward the analysis and design of managerial systems comprised of human, technological and economic resources.

Operations analysts address themselves to problems of production, distribution, marketing, industrial and governmental operations, public planning and services, military analysis and others. Their services are sought by all levels of government, public agencies, industry and non-profit research organizations.
Students may pursue graduate studies in specialized areas such as information science, system simulation, management science, experimental design, mathematical programming, social systems dynamics, production engineering, production and inventory models, queuing theory and applications, reliability and maintainability. Certificate programs are available for more limited graduate study in a wide range of specialized topics.

Graduate students come with diverse academic training. Most professionals in these areas of specialization receive the major part of their training at the graduate level. One ingredient common to our students is a desire to develop techniques for problem-solving and decision-making in a technological world.

**MASTER OF SCIENCE DEGREE**

The graduate curriculum leading to the degree of master of science in operations research is designed for engineers, scientists, and mathematicians who wish to broaden their prior training with work in operations research and for students with undergraduate background in this field who wish to pursue advanced studies.

A bachelor's degree and competence in calculus (equivalent to MA 103) are required for admission to the program. Applications should be made to the department with operations research indicated as the area of specialization.

Students are encouraged to seek waivers for all required courses in which they can demonstrate competence, so that they can use their time most effectively.

**Requirements for the Degree of Master of Science in Operations Research**

A. **Basic Required Courses**

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<th>Course</th>
<th>Units</th>
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<tr>
<td>MA 153</td>
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<tr>
<td>MA 561</td>
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</tr>
<tr>
<td>IE 600</td>
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<tr>
<td>IE 601</td>
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B. **Required Courses**

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<td>IE 632</td>
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<td>IE 650</td>
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C. **Major Electives (Select four courses)**

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<td>IE 611</td>
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<td>IE 618</td>
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<td>IE 619</td>
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<td>IE 637</td>
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D. **Other Relevant Electives**

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<tbody>
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</tr>
<tr>
<td>IE 601</td>
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</tr>
</tbody>
</table>

**MINIMUM TOTAL 36 UNITS**

**COMPUTER SCIENCE/OPERATIONS RESEARCH DUAL MASTER'S DEGREE PROGRAM**

The disciplines of computer science and operations research complement each other, both academically and professionally. Any eligible student may pursue master's degrees individually in these two areas. By taking advantage of the reduced credit requirement for a second M.S., qualified students can earn the two degrees with a total of 63 credits.

However, the student whose undergraduate background is in other scientific and engineering disciplines and who needs the computer science "orientation" courses and the operations research "basic required" courses would ordinarily require many more credits. For these students, the operations research faculty, in cooperation with the Computer Science Division, has developed a combination of courses which simultaneously satisfy the requirements for the master of science in computer science and the master of science in operations research.

By assigning credit in one program for basic core courses in the other, the requirements of both programs can be satisfied within the total of 63 credits. A student with superior preparation would have a greater choice of electives.
The student is assigned an adviser in each program. Upon completion, the student is awarded both the master of science in operations research and the master of science in computer science.

The requirements for admission to the dual program are a bachelor's degree in science, mathematics or engineering from an accredited school, and a superior academic record. The student must have completed calculus (through MA 103) and a year of university-level science.

Requirements for the Dual degrees
Master of Science in Computer Science and Master of Science in Operations Research

CS 530 Introduction to Computer Science
CS 540 Elements of Data Structures
CS 550 Assembly Language Programming
CS 560 Introduction to Logic & Automata
CS 560 Information Structures & Algorithms
CS 613 Computer Architecture I
CS 623 Operating Systems I
CS 637 Programming Languages
CS 641 Compiler Design & Construction I
Two of the following three:
CS 614 Computer Architecture II
CS 624 Operating Systems II
CS 642 Compiler Design & Construction II

MA 153 Elements of Linear Algebra
MA 551 Elements of Probability
IE 600 Engineering Economy
IE 608 Statistics
IE 631 Linear Programming
IE 632 Nonlinear Programming
IE 650 Queuing Systems I
IE 660 System Simulation I
One of the following two:
IE 618 Inventory Models
IE 619 Production Planning and Control
One course chosen from the bracketed sets in the M.S. (O.R) program not already represented above.
IE xxx

Total: 63 credits

DOCTOR OF PHILOSOPHY DEGREE

The department offers a program leading to the degree of doctor of philosophy in operations research. The general Polytechnic requirements for the doctor of philosophy degree are stated in this catalog under Degree Requirements. Specific requirements for the doctoral program may be found in the department's doctoral brochure.

Entrance to the doctoral program is contingent on passing the qualifying examination. This will consist of the Part I preliminary written examination. And the Part II major field written examination, an oral examination may also be required. An examination in one foreign language is required, ordinarily French, German or Russian.

The doctoral program requires a minimum of 90 units beyond the bachelor's degree, including a minimum of 24 units of dissertation. No more than 30 units of dissertation may be counted in the minimum total.

After passing the written qualifying examination, the candidate will select a thesis adviser and prepare a formal proposal for the dissertation research. A thesis committee will be appointed to judge the merit of the proposed research. After approval of this proposal, the doctoral candidate shall register for research. On completion of the dissertation, the candidate must pass an examination in its defense.

CERTIFICATE PROGRAMS

The department offers certificate programs designed for the professional with work experience. A certificate program requires five courses which are selected in line with the needs of the individual. Applicants for a certificate program must hold a bachelor's degree. On completion of the sequence with a B average or better, the individual is issued a certificate. Students who choose to work toward a master's degree are able, on admission, to apply all courses taken toward a certificate to the degree program. Additional information may be obtained from the department.

The certificate programs offered are:

Operations Research
IE 631 Linear Programming
IE 650 Queuing Systems I
IE 680 System Simulation I
Two of the following:
IE 618 Inventory Models
IE 619 Production Planning & Control
IE xxx Approved operations research elective

Basic Engineering Statistics
MA 551 Probability
IE 608 Statistics
IE 852 Appl. Regression & ANOVA
Two of the following:
IE 611 Statistical Quality Control
IE 851 Stochastic Processes
IE 953 Design of Experiments
IE 870 Games and Decisions

Mathematical Programming
IE 631 Linear Programming
IE 632 Nonlinear Programming
Three of the following:
IE 633 Integer Programming
IE 634 Dynamic Programming
IE 635 Advanced Linear Programming
IE 720 Optimum Seeking Methods
IE xxx Approved elective

UNDERGRADUATE COURSES

All undergraduate courses in operations research are listed in the Industrial Engineering section of this catalog.
GRADUATE COURSES

All graduate lecture and laboratory courses in operations research are listed in the Industrial Engineering section of this catalog.

OR 930-931 Readings in Operations Research I, II each 3 units
Individual reading of selected papers and current literature in specialized area of study, guided by faculty member. Prerequisites: approval of adviser, instructor and department head.

OR 935 Engineering Projects Related to Public Administration each 3 units
See Cooperative Program with New York University Graduate School of Public Administration for details.

OR 997 Thesis for Degree of Master of Science each 3 units
Original investigation on topic chosen by student. Conferences and progress reports required during work, and final written report required at completion, oral examination may be requested by department. Registration and degree credit beyond first six units require separate approval. Prerequisites: degree status and approval of supervising professor, adviser and department head.

OR 999 Dissertation for Degree of Doctor of Philosophy each 3 units
Doctoral dissertation must give evidence of and embody results of extended research in specific field of operations research, constituting original contribution. Candidate required to take oral examination on subject of thesis and on related topics. Minimum of 24 units required. Prerequisites: completion of qualifying examination and guidance committee's approval.

FACULTY

Walter Helly, Professor of Operations Research and Head of Industrial Engineering and Operations Research
B.A., Cornell University; M.S., University of Illinois; Ph.D., Massachusetts Institute of Technology
Stochastic modeling, tele- and vehicular traffic, urban systems

John T. Chu, Professor of Operations Research and Management Science
B.S., University of Chekiang (China); M.S., Ph.D., Iowa State University
Managerial decisions, behavioral approach, national and international affairs

Norbert Hauser, Professor of Industrial Engineering and Management Science
B.M.E., Cooper Union; M.I.E., Eng.Sc.D., New York University
Modeling of social systems, computer simulation, quality control

John H. K. Kao, Professor of Industrial Engineering and Operations Research
B.S., National Central University (China); M.S., Eng.Sc.D., Columbia University
Probability and statistics, quality control and reliability, scientific computing, electronic data processing

Joachim I. Weindling, Professor of Operations Research and System Engineering, and Director of Operations Research Program
B.M.E., City College of New York; M.S., Ph.D., Columbia University; Professional Engineer (N.Y., Pa.)
Mathematical programming, optimum design, economic evaluation

Herman Grau, Associate Professor of Industrial Engineering
B.M.E., Polytechnic Institute of New York; M.I.E., New York University
Methods, work measurement, project management, manufacturing engineering, industrial management

Seymour Kaplan, Associate Professor of Operations Research and Management Science
B.S., Newark College of Engineering; M.S., Ph.D., New York University
Economic modeling, linear programming

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management
B.Sc., Banaras Hindu University (India); M.S., Ph.D., University of Illinois
Production and operations planning, productivity analysis, project control

Vincent K. Omachonu, Instructor of Industrial Engineering and Operations Management
B.S.I.E., M.S., University of Miami
Productivity management, human factors

ADJUNCT FACULTY

George A. Hazelrigg, Jr., Adjunct Professor
B.S., M.S., New Jersey Institute of Technology; M.S.E., M.A., Ph.D., Princeton

Peter Meier, Adjunct Professor
B.S., Swiss Federal Institute of Technology (Zurich); M.S., Ph.D., University of Massachusetts

Lawrence M. Parks, Adjunct Professor
B.S., M.S., Ph.D., Polytechnic Institute of New York

Steven Kolman, Adjunct Associate Professor
B.S., M.B.A., New York University

Moira LeMay, Adjunct Associate Professor
B.S., Queens College; M.S., Ph.D., Pennsylvania State University

Robert A. Marose, Adjunct Associate Professor
B.S., Notre Dame; M.S., Stevens Institute of Technology, M.S., Adelphi University, Ph.D., Polytechnic Institute of New York

Andrew Sipos, Adjunct Associate Professor
Engineering Diploma, Technical University, Budapest; M.S.C.E., University of Pennsylvania
William Ying, Adjunct Associate Professor
B.S., Cornell University; M.S., Ph.D., Columbia University

Young W. Yoon, Adjunct Associate Professor
B.A., Yonsei University; M.B.A., New York University; Ph.D., Polytechnic Institute of New York

Asutosh Chakrabarti, Adjunct Assistant Professor
M.S., Calcutta University; M.S., New York University

Saibalesh Mukhopadhyay, Adjunct Assistant Professor
B.S., Calcutta University; M.S., Ph.D. Polytechnic Institute of New York

Chalm Steinberger, Adjunct Assistant Professor
M.S., Polytechnic Institute of New York

Peter Wan, Adjunct Assistant Professor
B.S., Taiwan Chung Yuen; M.S., Kansas State University

David Einbinder, Lecturer
B.S., City College of New York

Michael P. London, Lecturer
B.S., M.S., Ph.D., New York University

Walter Vasilasky, Lecturer
B.A., Rutgers University; M.A., University of Maryland; Ph.D., Courant Institute of Mathematical Sciences.
PHYSICAL EDUCATION

The major goal of the required physical education program is to educate and interest students in a wide variety of physical activities so they may develop skill and success while experiencing an optimum condition of physical fitness in terms of strength, speed, agility and endurance. The program teaches skills in interesting lifetime sports: tennis, golf, badminton, as well as innovative programs in aerobics, self defense, weight training, and cardiopulmonary resuscitation (CPR).

Athletics

The student athlete attending Polytechnic may compete in a far-reaching intercollegiate athletic program that encompasses every phase of sport. All full-time undergraduate students in good academic standing are eligible for positions on the seven varsity teams that carry the blue and white colors of Polytechnic in N.C.A.A. competition. Intercollegiate sports are baseball, basketball, cross-country, soccer, tennis, badminton, softball, football, handball, paddleball and golf.

Intramurals

Intramural sports enjoy substantial success at Polytechnic. All students, both undergraduate and graduate, are eligible for competition in badminton, basketball, football, tennis, handball, hockey, paddleball, softball, volleyball and wrestling. Winners of the intramural basketball and volleyball tournaments compete in the tristate area college intramural championships.

PHYSICAL EDUCATION COURSES

The department's aim is to provide a sound program of instruction and participation for all students in physical education.

Each undergraduate student is required to complete four semesters of physical education in any of the following course offerings.

PE 101 Team and Lifetime Sports 0:2:0
Fundamental conditioning exercises, basic skills and strategy needed while participating in team and carry-over sports, volleyball, basketball, soccer, tennis, badminton, softball, football, handball, paddleball and golf.

PE 102 Cardiopulmonary Resuscitation and Weight Training 0:2:0
This course is divided into two sections. One hour a week of CPR where the students will learn principles and techniques of how to maintain breathing and circulation in a victim suffering from cardiac arrest. In the second hour, each student participates in an individual weight-training program.

PE 103 Aerobics 0:2:0
Exercise program set to music. The aim of the course is to increase the cardiovascular performance of the students.

PE 104 Weight Training 0:2:0
Individual weight-training programs developed to produce increased strength and endurance through the use of isotonic and isometric exercises.

PE 101S Self Defense 0:2:0
Instruction in the art and skills of judo and karate as they apply to defending oneself in everyday situations.

Note: ROTC courses (MS 101, 102, 201, 202) may be substituted for PE 101-104.

FACULTY

Joseph Martini, Director of Physical Education and Athletics
B.S., Long Island University; M.S., Brooklyn College

Edward J. Collins, Instructor

Maureen Braziel, Instructor
B.A., Hunter College

Louis Zinser, Assistant Director of Athletics
B.S., University of Baltimore; M.S., Hofstra University
Physics

Physics is the basic science of the natural world—the science of matter, energy and motion. It is indispensable in the preparation for any engineering or scientific career.

The training of physics majors, at both the undergraduate and graduate levels, is basic and general. This broad training makes graduates less subject to the risks of obsolescence produced by the rapidity of technological change in modern life. The curriculum is designed to provide a background for careers in industry, government and education. Some physicists go into university teaching and research when they have completed their graduate education. Others go into science teaching at any one of many different levels. And physics graduates at all levels are employed in private industry, government agencies and research foundations for fundamental research and engineering. In addition, training in physics serves as valuable preparation for a great variety of science-based or science-connected careers.

Besides the very active field of solid-state and nuclear physics, other general areas in which physicists are now employed are the radio/television and electronics industries, the chemical industry and the fields of biophysics, space science and medical physics.

The Department of Physics grants the degrees of bachelor of science, master of science and doctor of philosophy in physics.

UNDERGRADUATE PROGRAM

The aim of the four-year undergraduate program in physics is to prepare students thoroughly for any one of the many careers for which a concentration in physics forms the base. For the majority of students, this means preparation for graduate school and further study leading to the master's or doctor's degree. For many others, it means professional work in industry, government or in high school teaching. In addition, some students use their major in physics as preparation for work in other fields such as mathematics, chemistry, biology, medicine, engineering, law, history of science, writing or business.

Our program's emphasis on fundamental knowledge, thorough analytic training and on the universal logic of science enables our physics students to take these different paths.

The structure of the undergraduate program is four-fold: formal instruction in the sciences, instruction in humanities and social sciences, informal instruction and additional activities.

Formal instruction in the sciences is described by the program of courses. This program includes—after the freshman year with its beginning courses in physics, chemistry and mathematics—a spiral sequence of courses in the three broad areas of mechanics, electromagnetic theory and modern physics, matched at each level to the student's increasing mathematical maturity. With this background, a senior is ready for theoretical physics and electives in solid-state, x-ray, nuclear physics or quantum theory. Specialized courses, such as optics, thermodynamics, computing and electronics are required, and additional courses in mathematics, chemistry or life sciences may be elected.

Instruction in the humanities and social sciences is built around the 32 credit hours of courses in the humanities and social sciences required of all physics majors. This department urges its students to choose additional courses in these areas. It believes that the natural curiosity that brought students to choose physics as a major should also be stimulated in other areas of intellectual activity, such as literature, psychology, poetry, music, economics and history.

Informal instruction accompanying the formal course work takes a variety of forms. Each student meets regularly with members of the physics faculty in informal conferences to discuss the student's work, review problems or talk physics.

All physics freshmen take a seminar on current advances in physics. All seniors participate in another seminar. In both seminars, students prepare talks on aspects of advanced topics in physics and present them to the critical audience of their peers and professors.

Many students spend some time in research, either assisting in the various research programs carried on by the faculty or working on a relatively independent research project assigned after consultation with a guidance professor. Undergraduate participation in research alongside graduate students and professors is becoming so important that it will probably soon enter the department's formal education structure. A number of juniors and seniors in the physics department now spend ten weeks each summer in such full-time research activity. Opportunities for guided research during the academic year also exist.

The department offers the opportunity for individual reading and advanced study under professional guidance and will accept satisfactory performance in a regular course examination as fulfillment of a course requirement.
Physics students have at their disposal a common study area in which they meet with other students for shop talk, for problem-solving and for the exchange of ideas.

Information about advanced placement of freshmen is included in section on Admissions.

Additional activities, in which all physics students are urged to participate, include the programs organized by the Physics-Math Society, by the chapter of Sigma Pi Sigma (the physics honor society) and by the local student chapter of the American Physical Society. Here the students listen to and meet speakers on various topics and participate in trips to industrial and government laboratories. Undergraduates are encouraged to come to the regular research colloquia where invited scientists discuss the latest advances in physics. They also attend meetings of the American Physical Society and other professional societies associated with the American Institute of Physics.

By means of these activities and through the structure of the department, students have a wide range of opportunities for interacting with their professors, their fellow students and with the world of physics. We believe that such interaction, leading to a college experience built around studying physics, is the most valuable preparation for any career in physics. We also feel that this blending of experiences leads to a real appreciation of the intellectual impact of physics and to an understanding of why so many of mankind's important thinkers have been attracted to physics and have added to its accomplishments.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE

The program requires 128 credits, including 46 credits of required courses in physics. The remaining credits are distributed among required technical courses, required humanities, social sciences courses, a foreign language requirement and restricted and free electives. (See "Typical Course of Study" on the following page.) The distribution is as follows:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 101-103, 111, 210, 232, 240, 303-304</td>
<td>1.5</td>
</tr>
<tr>
<td>313-314, 321, 335-336, 343, 350</td>
<td>3</td>
</tr>
<tr>
<td>CM 101, 102, 111, 112, 180, EE370, 374</td>
<td>3.5</td>
</tr>
<tr>
<td>MA 101-104, CS 111</td>
<td>3</td>
</tr>
<tr>
<td>HU 101, HU 200 and SS 104</td>
<td>3</td>
</tr>
<tr>
<td>or IS 140 and 141</td>
<td>3</td>
</tr>
<tr>
<td>Language (or equivalent)</td>
<td>9</td>
</tr>
<tr>
<td>Electives (7 MA, 3 PH, 11 Hum/Soc Sci)</td>
<td>21</td>
</tr>
<tr>
<td>Free electives</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>128</td>
</tr>
</tbody>
</table>

**Required Physics Courses:** The course format of the required courses may be lectures, recitations or guided reading. Any substitutions require the permission of the undergraduate adviser.

**Electives:** Elective courses are to be chosen in consultation with the departmental adviser. Seven elective credits must be in mathematics and three in physics. The remaining electives are free.

GRADUATE PROGRAMS

The Department of Physics offers graduate programs leading to the degrees of master of science and doctor of philosophy in physics. In addition, the Department of Physics cooperates with the Department of Chemistry in offering an interdisciplinary program leading to degrees in chemical physics.

Experimental research programs are carried out in solid state physics, low temperature physics, surface physics, x-ray physics, quantum optics, radiation physics, and medical physics in modern well-equipped laboratories. The x-ray diffraction laboratory, one of the country's largest, is equipped for all types of crystal analysis and has unique capabilities in high-resolution x-ray interferometry. Surface physics studies are carried out both in the department's extensive surface science laboratories and at various synchrotron radiation facilities (e.g., National Synchrotron Light Source at Brookhaven National Laboratories and Cornell High Energy Synchrotron Source). Areas of current theoretical research are in solid state physics and statistical mechanics within the theoretical condensed matter group, and also field-matter interactions, image restoration, and nuclear theory.

For admission to graduate study in physics, a Bachelor's degree in physics is required with preparation equivalent to intermediate courses in mechanics, electromagnetic theory, optics, thermodynamics, quantum mechanics, and atomic physics. Applicants with a degree in physics of different emphasis, or with a degree in other fields, may be admitted with undergraduate deficiencies if approved by the departmental adviser. All applicants are requested to take the Graduate Record Examination.

Applicants can apply for financial aid in the form of teaching fellowships, research fellowships, or partial tuition remission.
## Typical Course of Study for the Bachelor of Science Degree in Physics

### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
</tr>
<tr>
<td>CS 111</td>
<td>Introduction to Computing</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>5</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>PH 111</td>
<td>Introductory Physics I</td>
<td>3</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>0</td>
</tr>
</tbody>
</table>

### Second Semester

<table>
<thead>
<tr>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

### Sophomore Year

<table>
<thead>
<tr>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

### Junior Year

<table>
<thead>
<tr>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

Total credits for graduation: 128

1. Humanities and Social Sciences: Required courses (21 credits), include HU 101 and either HU 200, SS 104 or IS 440, 141 (9 credits), and ML 1 through 141 (12 credits). The modern language requirement must be satisfied in German, French, or Russian. Based on performance in prior language studies, the language requirement may, with approval of the Department of Physics, be replaced by other humanities or social sciences electives. Elective courses (11 credits): The student is strongly urged to select two or three courses from an area of concentration such as literature, communications, the arts, philosophy, comparative religion, political science, economics, history, anthropology, or psychology. Electives are chosen with the advisor's approval.

2. Math, physics and free electives (20 credits): Qualified upper-classman who are preparing for graduate school often include among these electives first year physics graduate courses, such as Theoretical Mechanics, Quantum Mechanics, Statistical Mechanics, Introduction to Nuclear and Elementary Particle Physics and Introduction to Solid-State Physics. Upon the approval of the undergraduate advisor, an appropriate distribution of such courses can substitute for PH 313, 314 and/or 343.
REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The requirements for the master of science in physics conform to the general Polytechnic requirements. (see "Degree Requirements")

The minimum course requirements for the master's degree are:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 667</td>
<td>Quantum Mechanics I</td>
<td>3</td>
</tr>
<tr>
<td>PH 953-954</td>
<td>Graduate Seminar I, II</td>
<td>3</td>
</tr>
<tr>
<td>PH 901-902</td>
<td>Physics Colloquium I, II</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective Courses</td>
<td>30</td>
</tr>
</tbody>
</table>

With the approval of the graduate adviser, up to nine units of equivalent courses taken elsewhere may be used to fulfill individual course requirements. Registration for PH 901-902 Physics Colloquium is required each semester for all full-time graduate students. Elective courses may include a 6-unit project in physics or a 12-unit thesis in physics. The choice of a project or thesis option and the choice of elective courses should be made with the approval of the graduate adviser. No comprehensive examination is required for the master's degree in physics.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

The requirements for the Ph.D. in physics conform to the general Polytechnic requirements. Entrance into a doctoral program of study and research is contingent on the candidate's passing the departmental qualifying examination. A student entering with a bachelor's degree will normally take the qualifying examination after one year of study. The examination, given once a year at the beginning of the fall semester, consists of written questions in classical mechanics, electromagnetic theory, statistical mechanics, and quantum mechanics followed by an oral examination. Sample examination questions are available in the departmental office.

After passing the qualifying examination, the candidate suggests a guidance committee consisting of a prospective research director, a minor adviser, and at least one additional member of the physics faculty. The guidance committee must approve the candidate's choice of courses, will conduct the dissertation, precis examination and the final dissertation oral examination, and must approve the dissertation, before the degree can be awarded.

The minimum course requirements for the Ph.D. degree in physics are:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 669-760</td>
<td>Quantum Mechanics III, IV</td>
<td>6</td>
</tr>
<tr>
<td>PH 953-954</td>
<td>Graduate Seminar I, II</td>
<td>3</td>
</tr>
<tr>
<td>PH 901-902</td>
<td>Physics Colloquium I, II</td>
<td>0</td>
</tr>
<tr>
<td>PH 999</td>
<td>Research in Physics</td>
<td>24</td>
</tr>
</tbody>
</table>

With the approval of the graduate adviser, equivalent courses taken elsewhere may be used to fulfill individual course requirements, although a minimum of 30 units including the dissertation units must be taken at Polytechnic. A general knowledge of more than one area of physics is expected of all Ph.D. candidates. There is no foreign language requirement for the Ph.D. in physics. Registration for PH 901-902 Physics Colloquium is required each semester for all full-time graduate students. Registration for PH 999 Research in Physics, once begun, is required each semester consecutively until the completion of the thesis unless leave is formally granted. Until the appointment of the guidance committee, the choice of physics courses, minor courses, and elective courses should be made with the approval of the graduate adviser.

Approximately three months before the completion of the dissertation, a precis of the proposed work will be circulated to the physics faculty and a precis examination held. Upon completion of the dissertation, an oral thesis defense will be held.

CHEMICAL PHYSICS PROGRAM

Chemical physics is an interdisciplinary program designed to train students for careers in those areas common to chemistry and physics. Jointly administered by the Department of Chemistry and Physics, it provides, within the scope of a graduate program, an unusual overlap of studies, emphasizing those aspects which are closely related to both fields.

UNDERGRADUATE COURSES

<table>
<thead>
<tr>
<th>PH 091-092 Concepts of Contemporary Physics I, II</th>
<th>3:3:4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory course, including topics in both classical and modern physics. Emphasis on development of physics as a dynamic cumulative process through the interplay of experiment and theory. Co/Prerequisites: MA 091-092.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PH 101 Introductory Physics I</th>
<th>3:0:3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of the dynamics of particles and systems of particles within the general principles of symmetry and the conservation laws of physics. Co/Prerequisite: MA 101.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PH 102 Introductory Physics II</th>
<th>3:1:1:4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuation of PH 101. Thermodynamics and kinetic theory of gases. Electromagnetic fields and forces and their interactions with particles. Principles and instruments of classical and modern measurements. Lab fee required. Prerequisite: PH 101 and Co/Prerequisite: MA 102.</td>
<td></td>
</tr>
</tbody>
</table>
PH 103 Introductory Physics III 2/1:6:3
Continuation of PH 102. Propagation of waves, particularly as illustrated by the study of physical and geometrical optics. Lab fee required. Prerequisite: PH 102.

PH 111 Freshman Seminar in Current Physics 1:0:1
Analysis and discussion of selected topics of current interest in physics emphasizing concepts and the underlying framework of physical understanding. Topics are discussed from various areas of current research such as astrophysics, atomic and nuclear physics, the solid state and biophysics. Lectures and discussion. Readings in literature. Visiting scientists.

PH 210 Elementary Mechanics 3:0:3

PH 230 Introduction to Atomic and Nuclear Physics 2:0:2
Properties of atoms, nuclei and electrons, photoelectric effect, quantization, Bohr atoms and spectra, wave nature of particles, electron spin and periodic table, radioactivity, structure of nucleus, nuclear reactions. Prerequisite: PH 103.

PH 232 Introduction to Modern Physics 3:1:1:3
Kinetic theory, relativity, quantization, x-rays, atomic physics, solid state, nuclear, high energy physics. Lectures, discussion sessions and six laboratory sessions during the semester. Prerequisite: PH 103.

PH 240 Optics 3:0:3
Principles of reflection, refraction, photometry, interference, diffraction, polarization, dispersion, scattering, application to lenses, optical instruments, interferometers, resolving power, spectra. Prerequisite: PH 103.

PH 281 Astronomy and Astrophysics 3:0:3
Historical development. Traditional and modern observational techniques. Theories of planets, stars, galaxies. High points of current advances in astrophysics and cosmology. Given on demand. Prerequisite: PH 103.

PH 303-304 Physical Measurements I, II each 1:3:2
Precision measurements in mechanics, heat, electricity, optics, modern physics. Lab fee required. Given alternate years. PH 303 prerequisite: PH 232 and Co/Prerequisite PH 335. PH 304 prerequisite: PH 303 and Co/Prerequisite PH 335.

PH 313-314 Introduction to Theoretical Physics I, II each 3:0:3
Provides a foundation for more advanced graduate courses by developing mathematical methods used in classical theoretical physics. Topics include Lagrange's equations, vibrating strings and membranes, flow of fluids, flow of heat, electrostatics, electrodynamics, Maxwell's equations. PH 313 prerequisites: PH 210 and PH 321. PH 314 prerequisite: PH 313.

PH 321 Electricity and Magnetism 4:0:4
Properties of the electrostatic, magnetostatic and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. Prerequisite: MA 104.

PH 335-336 Introduction to Quantum Mechanics I, II each 3:0:3
Introduction to electronic and nuclear structure of the atom. Relativity, wave mechanics, natural and artificial radioactivity, fission, cosmic rays. Fundamental experiments and postulates of wave and particle physics. PH 335 prerequisite: PH 232. PH 336 prerequisite: PH 335.

PH 343 Thermodynamics and Kinetic Theory 4:0:4

PH 372 X-Ray Diffraction 2:3:3
Production and properties of x-rays. Elements of crystallography. Stereographic projection. Powder and single crystal diffraction techniques. Structure and crystal orientation. Stress analysis and phase diagram determination by x-ray techniques. Qualitative and quantitative chemical analysis by x-ray techniques. Prerequisites: MA 104 and PH 103. Also listed under MT 412.

PH 381-382 Reading Course in Physics I, II each 2 credits
Reading course in special topics in physics, supervised by an appropriate staff member. Prerequisites: physics major, junior standing and departmental approval.

PH 390 Senior Seminar 2:0:2
Topics of general interest prepared, reported and discussed by the students. Prerequisite: PH 336.

PH 391-394 Bachelor's Thesis in Physics each 2 credits
An individual investigation involving theoretical, experimental and bibliographic study of some problem of interest to physicists. Students may register for thesis in parts as noted. Total credits determined in consultation with adviser.

PH 398 Senior Honors Work in Physics credit to be arranged
Independent work undertaken by qualified junior students in physics. Course material arranged by a faculty steering committee.

GRADUATE COURSES

PH 601-602 Physics for Chemists I, II each 3:4:0:4
For doctoral candidates in chemistry with only a general physics background, gives training in classical physics: electricity and magnetism, geometrical and physical optics. May not be used for degree requirements in physics. Required for Ph.D. candidates in physical chemistry. PH 601 prerequisites: MA 104 and PH 107. PH 602 prerequisite PH 601.

PH 603 Graduate Laboratory* 0:4:3
Practice in experimental research techniques through setting up and carrying out experimental projects in classical and modern physics. Given alternate years. Lab fee required. Prerequisite: PH 304.

PH 604† Physics of Stars* 2:4:0:3
Discussion of internal constitution of stars with emphasis on nuclear reactions and generation of energy. Current theories of development of stars and of giant and dwarf stars. Prerequisite: PH 336.
PH 605-606† Special Techniques in Experimental Physics I, II each 0.3:1
Concerned with a range of specialized techniques and processes of modern experimental physics. Depending on requirements of thesis student and recommendation of advisor, concentration on advanced laboratory skills or area such as vacuum techniques, thin films, preparation of samples for solid-state studies, crystal growing, cryogenics and instrument design. Emphasis on intensive training in those particular skills required in student's research endeavors. Permission of student's advisor and of director of the course required. May be taken for a maximum of two semesters. Prerequisite: concurrent thesis registration.

PH 607 Mathematical Methods of Physics I† 2½:0:3
Review of vector and tensor analysis. Introduction to complex variable theory. Special functions of mathematical physics. Differential equations of mathematical physics. Emphasis on unifying role of mathematics in physics on physical concepts and problems. Prerequisites: PH 322 or equivalent and Co/Prerequisite: PH 313 or equivalent.

PH 608 Mathematical Methods of Physics II† 2½:0:3

PH 512‡ Microcomputer Instrumentation for Scientific Research∗ 2½:0:3
Fundamentals of digital electronics and minicomputers, computer-automated laboratory instrumentation, programming and interfacing required for data acquisition and control in scientific research, experiments with minicomputers and with laboratory apparatus interfaced directly to minicomputers. Lab fee required. Prerequisite: instructor's permission
Also listed under CM 760 and BE 623

PH 615 Theoretical Mechanics I 2½:0:3
Principles of particle and rigid body dynamics. Lagrange's equations. Small vibrations of coupled systems, normal modes of oscillation. Prerequisite: PH 313 or equivalent.

PH 616 Theoretical Mechanics II 2½:0:3
Hamiltonian mechanics. Transformation theory of mechanics including the Hamilton-Jacobi and Poisson bracket formulation. Lagrangian formulation of mechanics of continuous media. Prerequisite: PH 615.

PH 623 Electromagnetic Theory I 2½:0:3

PH 524 Electromagnetic Theory II 2½:0:3
Interaction of electromagnetic fields with material media from classical viewpoint. Macroscopic description of dielectric, magnetic and conducting materials, energy relations, dispersion, and attenuation in dielectrics and ionized media. Wave propagation in anisotropic crystals and fibers, waves in inhomogeneous media. Prerequisite: PH 623.
Also listed under EL 673

PH 533-634† Introduction to Nuclear and Elementary Particle Physics I, II each 2½:0:3
Survey of fundamental properties of atomic nucleus and its constituents. Two-body problems at low energies and the theory of nuclear forces. Nuclear radioactivities such as alpha, gamma- and beta-decay. General features of nuclear reactions and of the various nuclear models. Basic properties of elementary particles, their modes of decay, interactions, classifications and invariance laws. PH 633 prerequisite: PH 336 or PH 634 prerequisite. PH 633.

PH 635 Biophysics I† 2½:0:3
Physical properties of biological systems. Natural properties of biological components. Structural strength, elasticity of bones, muscle, other tissue. Flow properties through tissue, diffusion of gases and liquids, flow-through vessels. Comparative analysis, models, trace analysis. Effects of stimuli on various body organs and mechanisms. Temperature effects, electrical excitations. Prerequisite: PH 335 or equivalent.
Also listed under BE 603

PH 636 Biophysics II 2½:0:3
Transport processes in animals and models of the specific organs. Application of radionuclides and dyes for static and dynamic imaging. Theoretical and practical aspects of nerve conduction with detailed discussion of the Hodgkin-Huxley and current models. Prey-predator interactions in biological systems on the cellular level, in radioimmunoassays and in population control. Prerequisite: PH 635.
Also listed under BE 604

PH 637 Radiation Physics with Biological and Medical Applications∗ 2½:0:3
Principles of atomic and molecular physics with stress on the problems of radiation and biological effects of x-radiation. Radiation dosimetry including internal and external exposures and relationship between dose, biological behavior of radionuclides, radiation and thermal radiation. Prerequisite: PH 335 or equivalent
Also listed under BE 605

PH 651-652† Introduction to Solid-State Physics I, II each 2½:0:3
Survey of phenomena and introduction to theory of physics of crystalline solids. Topics from thermal, magnetic, electrical and optical properties of metals, insulators and semiconductors. PH 651 prerequisite: PH 336. PH 652 prerequisite. PH 651.

PH 553 Statistical Mechanics I 2½:0:3
Also listed under EL 651

PH 564 Statistical Mechanics II 2½:0:3
Also listed under EL 652

PH 567-568 Quantum Mechanics I, II each 2½:0:3
Also listed under EL 655-656

PH 669-670 Quantum Mechanics III, IV each 2½:0:3
Theory of measurement and connection with classical dynamics. The Dirac formulation, transformation theory, scattering theory and introduction to the theory of radiation. PH
PH 671 X-Ray Diffraction I* 2½:0:3
Theory of x-ray scattering, crystallography and crystal optics, diffraction by crystalline materials, space group theory, theory of x-ray diffraction methods, including Laue techniques, rotating crystal and moving film methods, single crystal diffraction: Introduction to powder methods.

PH 672† X-Ray Diffraction II* 2½:0:3
The interpretation of x-ray powder data. Theory and methods of crystal structure analysis, crystal size determination, scattering by amorphous substances, crystal perfection, small angle scattering. Prerequisite: PH 671.

PH 673-674† X-Ray Diffraction Techniques I, II 0:4:3
Laboratory course. The generation, detection and properties of x-rays. Orientation of single crystals. Powder methods: interpretation of patterns and applications to solid state problems. Determination of space groups. Intensity measurements. Stress-strain analysis, small-angle scattering and scattering by amorphous materials. Lab fee required. PH 673 Co-Prerequisite: PH 671. PH 674 Prerequisite: PH 673 and Co-Prerequisite: PH 672.

PH 676 Methods of Crystal Structure Determination* 2½:0:3
The theory of crystal structure analyses. Trial and error methods, the Patterson function and electron density maps. Direct methods. Least squares refinement procedures. Computing methods. Prerequisite: PH 672.

PH 751-752 Theory of Solids I, II* each 2½:0:3
Quantum and statistical mechanics of the band theory of solids as applied to electrical, thermal and optical properties of metals, semiconductors and insulators. Prerequisite: PH 664 and PH 658. PH 752 prerequisite: PH 751.

PH 753-754 Crystal Dynamics I, II* each 2½:0:3
Discussion of the particular physical properties of crystals arising from anisotropy of matter constants. Topics include thermal, electrical, optical and elastic properties and effects arising from coupling of these properties. Interpretation of these material constants according to modern atomistic theory and principles of crystal symmetry. Prerequisite: PH 753 prerequisites: PH 616 and PH 624. PH 754 prerequisites: PH 668 and PH 753.

PH 761-762 Relativistic Quantum Mechanics and Field Theory I, II* each 2½:0:3

PH 763-764 Nuclear Theory I, II* each 2½:0:3
Summary of present knowledge of fundamental properties of nuclear forces, nuclear reactions, nuclear structures, nuclear radiation and the theory of beta-decay. Emphasis on models of nuclear structure and nuclear reactions. Prerequisite: PH 670 or equivalent.

PH 765-766 High-energy Physics and Elementary Particle Theory I, II* each 2½:0:3
Basic properties of particles, their interactions and invariance laws of particle physics. Topics include fundamental properties and quantum numbers of the elementary particles, classification of interactions, invariance under space reflections, time reversal, charge conjugation, isotopic spin, calculation of cross-sections, branching ratios, lifetimes. Discussion of the higher symmetry schemes of SU(3), SU(6), etc. Field theory and second quantization introduced as necessary. PH 755 prerequisite: PH 670. PH 766 prerequisite: PH 765.

PH 780 Special and General Theory of Relativity* 2½:0:3
Introduction to Einstein's theory of relativity, Minkowski space-time, relativistic mechanics and electrodynamics. Applications of theory with special reference to high-energy physics, gravitation and principle of equivalence, Riemannian geometry, tensor calculus and Einstein's theory of gravitation, approximate and rigorous solutions, observational tests of the theory, theory of ponderomotive equations. Prerequisites: PH 616 and PH 624 or equivalent.

PH 801-802 Selected Topics in Advanced Physics I, II* each 2½:0:3
Current or advanced topics of particular interest to graduate students. Subject matter changes each year determined by student and faculty interest. May be given in more than one section. Consult department office for current offerings.

PH 953-954 Graduate Seminar I, II each 3 units
Prepared presentation by participating students and discussion of topics in physics of current interest and from the literature.

PH 955-956 Reading in Physics I, II each 2½:0:3
Individual reading of selected papers and current literature in a specialized field of physics guided by a faculty member. Prerequisite graduate adviser's and supervising faculty member's permission.

PH 999 Research in Physics each 3 units
An original investigation in some branch of physics or chemical physics, which may serve as basis for the degree of master of science or doctor of philosophy, to be carried out under the direction of a member of the Department of Physics. Chemical physics majors should register for appropriate CM courses. The number of research credits registered for each semester should reflect realistically the time to be devoted to research. Prerequisites: degree status and graduate adviser's and research director's consent.

FACULTY

Ronald D. Parks, Professor and Head of Physics
B.S., Kansas State University; M.S., Ph.D., Stanford University
Surface and condensed matter physics

Stephen Arnold, Professor of Physics
B.S., University of Toledo; M.A., Ph.D., CCNY
Organic solid-state and microparticle photo-physics

Raphael Aronson, Professor of Nuclear Engineering and Physics
B.S., University of Minnesota; M.A., Ph.D., Harvard University
Transport theory
Patrick T. Cahill, Professor of Physics  
B.S., M.S., University of New Hampshire; Ph.D., Harvard University  
Medical physics, atomic physics

Deo C. Choudhury, Professor of Physics  
B.Sc., M.Sc., University of Calcutta (India); Ph.D., University of California  
Theoretical nuclear physics

Hellmut J. Juretschke, Professor of Physics  
B.S., M.A., Ph.D., Harvard University  
Surface and condensed matter physics

Terje Kjeldaas, Jr., Professor of Physics  
B.S., Polytechnic Institute of Brooklyn; M.A., Columbia University; Ph.D., University of Pittsburgh  
Theoretical solid state and atomic physics

Nathan Wainfan, Professor of Physics  
B.E.E., M.S., New York University; Ph.D., University of Southern California  
X-ray physics, gas discharges

Hilda Bass, Associate Professor of Physics  
B.A., Hunter College; M.A., Smith College  
Physics education

Walter Kiszenick, Associate Professor of Physics and Nuclear Engineering  
B.S., Brooklyn College; M.S., Ph.D., Polytechnic Institute of Brooklyn  
X-ray diffraction, medical physics

Meir Menes, Associate Professor of Physics  
B.S., Cooper Union; Ph.D. New York University  
Experimental solid-state physics, gaseous electronics

Peter Riseborough, Associate Professor of Physics  
B.S., Ph.D., Imperial College (England)  
Theoretical condensed matter physics

Donald B. Searl, Associate Professor of Physics  
B.A., Leigh University; Ph.D., Princeton University  
Quantum optics, atomic physics

Marten L. denBoer, Assistant Professor of Physics  
B.A., Calvin College, M.S., Ph.D., University of Maryland  
Surface and condensed matter physics

Peter Hanggi, Assistant Professor of Physics  
B.S., College of Mathematics and Natural Sciences, Basel; M.S., Ph.D., University of Basel (Switzerland)  
Statistical mechanics

K. Ming Leung, Assistant Professor of Physics  
B.S., University of Missouri; Ph.D., University of Wisconsin  
Theoretical condensed matter and surface physics

Andrew Zangwill, Assistant Professor of Physics  
B.S., Carnegie-Mellon University, Ph.D., University of Pennsylvania  
Theoretical surface and condensed matter physics

ADJUNCT FACULTY

Hubert W. Schleuning, Adjunct Research Professor of Physics  
M.A., New York University; M.E., Polytechnic Institute of Brooklyn

Benjamin Bloch, Adjunct Assistant Professor of Physics  
B.S., Columbia University; Ph.D., Polytechnic Institute of Brooklyn

EMERITUS FACULTY

John J. Dropkin, Professor Emeritus  
B.A., Columbia University, M.S., Ph.D., Polytechnic Institute of Brooklyn  
Solid-state physics

Paul P. Ewald, Professor Emeritus  
Ph.D., University of Munich (Germany)  
X-ray physics

Benjamin Post, Professor Emeritus  
B.S., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn  
X-ray physics, crystallography, solid-state chemistry
POLYMER SCIENCE 
AND ENGINEERING

For many years, Polytechnic Institute has had a tradi-
tional commitment to a strong polymer program of
worldwide renown. At the present time, the Depart-
ments of Chemical Engineering and Chemistry jointly
offer graduate programs leading to the degree of
master of science and doctor of philosophy in polymer
science and engineering.

GRADUATE STUDY

An undergraduate degree in either chemical engineer-
ning or chemistry with a mathematics background which
includes at least one course in differential equations
is usually required for admission to the graduate pro-
gram. Applicants with degrees in other fields or from
other colleges may be admitted with undergraduate
or graduate deficiencies after the consent of a graduate
adviser is given.

The program leading to the master of science degree
is designed to meet the needs of engineers and
chemists well versed in the fundamental principles of
polymer science and engineering.

REQUIREMENTS FOR THE MASTER OF
SCIENCE DEGREE IN POLYMER SCIENCE
AND ENGINEERING

Candidates for the degree master of science in
polymer science and engineering are to plan their
programs in accordance with the following re-
quired courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 917</td>
<td>Introduction to Polymeric</td>
<td>3</td>
</tr>
<tr>
<td>CH 921</td>
<td>Polymer Processing</td>
<td>3</td>
</tr>
<tr>
<td>CH 922</td>
<td>Polymer Processing Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>CH 926</td>
<td>Engineering Properties of Polymers</td>
<td>3</td>
</tr>
<tr>
<td>CM 771</td>
<td>Introductory Polymer Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CM 783</td>
<td>Laboratory Methods in Polymer Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CH 991-992</td>
<td>Seminar</td>
<td>9</td>
</tr>
</tbody>
</table>

Chosen Electives* from such courses as: CH 862, CH
923, CH 933, CH 940-941, CM 760, CM 772, CM 781,
CM 782, CM 785, CM 801, CM 905, AM 603-604, AM
505, AM 625, MT 412, MT 603, MT 620, PH 673-674,
PH 676

Project/Thesis Option

Either

CH 930     Guided Studies in Polymer
Science and Engineering  6

Electives—from above listing  3

or

CH 987     Master's Thesis  9

Total 36

REQUIREMENTS FOR THE DOCTOR OF
PHILOSOPHY IN POLYMER SCIENCE
AND ENGINEERING

The doctor of philosophy in polymer science and
engineering program includes advanced graduate
work for qualified students interested in research and
development. Students enrolled in the program may
select elective courses either from polymer chemistry or
from polymer engineering offerings. Polymer science
and engineering may also be chosen as a minor by
students in the chemistry department or the chemical
engineering department.

Programs of study are planned individually with each
candidate by members of the Departments of Chemical
Engineering and Chemistry. Systematic study toward
the Ph.D. is carried out under the direction of a
guidance committee appointed by the vice president
for research and graduate affairs for each candidate.
The program is planned to give students a thorough
polymer science and engineering background accom-
panied by study in a minor field chosen by the can-
didate. The student must pass a comprehensive qualifi-
ing examination in polymer science and engineering,
exhibit a reading knowledge in a foreign language, and
present a doctoral dissertation.

Each candidate for the doctorate must complete a
minimum of 90 units of academic work beyond the
bachelor's degree, including a minimum of 30 units of
dissertation research. Although the student may
elect to take more than 30 units of Ph.D. thesis, only 30
units of Ph.D. thesis can be counted in the required 90
unit minimum, and these must be taken at Polytechnic.
Once the student has started the dissertation,
registration must be continuous (excluding the summer
session) until it is completed and accepted. Of the
90 units, a minimum of 30 units must be taken at

*All electives are to be chosen in conference with the graduate adviser.
Polytechnic. A minimum of 48 graduate units beyond the bachelor's degree (not including Ph.D. thesis) in polymer science and engineering subject will be required, of which at least 16 units must be taken at Polytechnic. A minor is required within a science or engineering department and should consist of at least 12 units.

Attendance is required at the chemical engineering or polymer science and engineering seminars for at least four semesters. Each student must maintain an overall B average in those courses submitted for the doctoral degree.

For a Ph.D. degree in polymer science and engineering, the following courses are required and may be used to complete the 48 graduate units required:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 772</td>
<td>Synthesis of High Polymers</td>
<td>3</td>
</tr>
<tr>
<td>CM 781</td>
<td>Solution Properties of High Polymers</td>
<td>3</td>
</tr>
<tr>
<td>CM 782</td>
<td>Macromolecules in the Solid State</td>
<td>3</td>
</tr>
<tr>
<td>CM 783</td>
<td>Laboratory Methods in Polymer Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CH 917</td>
<td>Introduction to Polymeric Materials</td>
<td>3</td>
</tr>
<tr>
<td>CH 921</td>
<td>Polymer Processing</td>
<td>3</td>
</tr>
<tr>
<td>CH 922</td>
<td>Polymer Processing Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>CH 926</td>
<td>Engineering Properties of Polymers</td>
<td>3</td>
</tr>
</tbody>
</table>

Total 24 units

Students interested in the Ph.D. program should obtain a brochure outlining procedures and requirements, which is available from the office of the polymer science and engineering program director.

**GRADUATE COURSES**

**CH 862 Rheology of Non-Newtonian Fluids** 2.5:0.3

**CH 917 Introduction to Polymeric Materials** 2.5:0.3
Principles of technological aspects of polymerization, compounding and processing of polymeric materials, their properties and applications. Thermoplastic materials such as polyethylene, polypropylene, poly vinyl chloride, polyamides, acrylics and engineering plastics will be discussed. Thermoplastic materials to be covered include: phenolics, epoxies, unsaturated polyesters, amorphous polymers, polyurethanes and silicones. Prerequisite: CM 123 or equivalent.

**CH 921 Polymer Processing** 2.5:0.3
Applications of engineering principles of polymer processing.

Study of non-Newtonian polymeric systems. Extrusion theory and applications. Discussions and problem-solving in compression, transfer and injection molding, thermforming and plastification, as well as other polymer engineering processes. Prerequisite: CH 220 and CH 221 or instructor's permission.

**CH 922 Polymer Processing Laboratory** 0:4:3
Laboratory study of engineering principles and processes involved in polymer processing and analysis. Experiments include injection molding, extrusion, thermforming, mixing and compounding, melt rheology, flat- and blown-film extrusion, blow molding, etc. Prerequisite: CH 921.

**CH 923 Industrial Polymerization Processes** 2:5:0.3
Analytical study of principal processes used to synthesize polymers, including polymer engineering operations, equipment polymerization control, instrumentation, process economics. Emphasis on development and solution of polymer plant engineering problems. Prerequisite: CM 771.

**CH 926 Engineering Properties of Polymers** 2.5:0.3

**CH 939 Coatings Technology** 2.5:0.3

**CH 940-941 Selected Topics in Polymer Science and Engineering I, II** each 2.5:0.3
Topics of special interest in polymer science and engineering as announced in advance of particular semester offering. Prerequisite: advisor's approval.

**CM 771 Introductory Polymer Chemistry** 2.5:0.3
Synthesis of polymers by step reaction and addition polymerization, formation of three-dimensional networks, block and graft polymers, polymer degradation, characterization of polymers in solution, rubber elasticity, polymer crystallization, spectroscopic techniques for polymer studies, properties of commercial polymers. Prerequisites: CM 123, CM 125 and CM 162.

**CM 772 Synthesis of High Polymers** 2.5:0.3

**CM 781 Solution Properties of High Polymers** 2:5:0.3
Application of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, viscosity, diffusion, ultracentrifuge sedimentation, flow birefringence, polarimetry, spectroscopy and other techniques to characterize low-molecular-weight solvents and dissolved macromolecules. Properties of polyelectrolytes, association in solutions containing macromolecules and reaction kinetics in macromolecular solutions also discussed. The
course is designed to cover both synthetic and biological macromolecules. Prerequisites: CM 161, CM 162, and CM 771 or CM 783.


CM 783 Laboratory Methods in Polymer Chemistry 0:5:3 Experiments on free radical, condensation, ionic and copolymerization, absorption, and NMR spectroscopy, intrinsic viscosity, light scattering, gel permeation chromatography, x-ray diffraction, thermogravimetric analysis, differential scanning calorimetry, dilatometry, concentrated solution viscosity, and other aspects of polymer synthesis and characterization. Lab fee required. Prerequisite: CM 771.

CM 785 Special Topics in Polymer Chemistry 2/5:0:3 Presentation at intervals of various advanced or specialized topics in polymer chemistry.

PROJECT, THESIS AND SEMINAR

CH 930 Guided Studies in Polymer Science and Engineering 6 units, each 2 units Selection, analysis, solution and presentation of a comprehensive report of some problem involving polymer science and engineering, such as polymer synthesis, processing, evaluation, equipment design, etc. Conducted under supervision of staff member. Conferences scheduled. Candidates for master's degree required to submit three unbound copies of typewritten project report to advisers one week before last day of classes. Prerequisite: degree status.

CH 987 Thesis for Degree of Master of Science in Polymer Science and Engineering 9 units, each 3 units Thesis for master's degree in polymer science and engineering should give results of original investigation of a problem in polymer science and engineering. Thesis may involve experimental research, theoretical analysis, or process design, and possibly a combination thereof. Candidates for a master's degree are required to submit four typewritten unbound thesis copies to advisers before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

CH 989 Dissertation for Degree of Doctor of Philosophy in Polymer Science and Engineering 30 units, each 3 units Dissertation must give results of independent investigation of a problem in polymer science and engineering and may involve experimental and/or theoretical work. Thesis must show ability to do creative work and that an original contribution has been made to polymer science and engineering, which is worthy of publication in recognized journals. The candidate is required to take an oral examination on subject of thesis and related topics. Candidates for a doctor's degree are required to submit five unbound thesis copies to advisers before or on seventh Wednesday prior to commencement. Prerequisite: degree status and a qualifying examination on quantitative aspects of polymer science and engineering.

CH 991-992 Seminar in Chemical Engineering 0:2:5:0 Recent developments in the field of chemical engineering and polymer science and engineering presented through lectures given by engineers from industry, research, and educational institutions, by staff members, and by qualified graduate students. Required for two semesters of all graduate students seeking degrees.

FACULTY

Chang-Dae Han, Professor of Chemical Engineering, Director of Polymer Science and Engineering Program

Bernard J. Bulkin, Professor, Vice President for Research and Graduate Affairs

Frederick Eirich, Distinguished Professor of Polymer Chemistry

Herbert Morawetz, Institute Professor, Professor of Polymer Chemistry

Yoshiyuki Okamoto, Professor and Head of Chemistry

Eli M. Pearce, Professor of Polymer Chemistry and Chemical Engineering, Dean of Arts and Sciences

Arnold Reiser, Research Professor and Deputy Director of the Institute for Imaging Sciences

Giuliana Tesoro, Research Professor of Chemistry, Ph.D., Yale University

Otto Vogl, Herman F. Mark Professor of Polymer Chemistry

Jovan Mijovic, Associate Professor of Chemical Engineering

William T. Winter, Associate Professor of Polymer Chemistry
SOCIAL SCIENCES

UNDERGRADUATE PROGRAM

The department offers a modern program of study leading to the degree of bachelor of science in social sciences. This core curriculum was conceived, first, as an attempt to meet increasing needs for specialists in the social sciences who have more than just a passing familiarity with computers, the physical sciences, mathematics and the humanities. Thus the program is designed to draw on the rich resources available at Polytechnic; the students are offered specialized training in the social sciences in a setting noted for its scientific and technical excellence. Secondly, social science majors will have the opportunity to work closely with members of the faculty in their areas of interest. Thirdly, the degree's presentation is interdisciplinary, with emphasis on developing an integrated historical, economic, behavioral and cultural understanding of human society and civilization. Within the general core curriculum, the student may major in one of three areas: history and history of science and technology, behavioral science (anthropology, psychology, sociology and politics) or economics. Each of these is described in detail below.

More and more occupations and professions require individuals firmly grounded in the social sciences. Accordingly, our graduates can look forward to employment opportunities in governmental agencies, foundations and private industry or to independent professional practice. Specific fields in which a social science background is useful include teaching at all levels; applied social research on problems involving race, poverty, education, urban and national planning and foreign aid; managerial and personnel operations; and the practice of law and medicine.

The department is also responsible for the social science courses that are an essential part of the general education and professional training of scientists and engineers at Polytechnic. The foundation provided in the social sciences helps prepare students for leadership in industry, education and government. In keeping with the educational ideals of Polytechnic, it is also the aim of the department to prepare students for active roles of responsible citizenship in a complex society.

HISTORY AND THE HISTORY OF SCIENCE AND TECHNOLOGY

Courses in history emphasize the elements of social and economic change in various areas and periods since the Renaissance. Both theoretical discussion and practical response are treated in order to elucidate the deeper meaning of historical movements more clearly than the more traditional political narrative. The methods and conclusions of related work in economics and the behavioral sciences are applied to this historical analysis.

The basic sequence on the history of Western civilization familiarizes students with political, economic, social, cultural and intellectual developments in European history since the Middle Ages. It also introduces them to original documents and to a range of scholarly interpretations. An introductory course on the modern world emphasizes the conflict of ideologies in the twentieth century and the history of non-Western societies. Students are also given the opportunity to analyze and discuss the best historical scholarship in a variety of special subjects: history of science and technology, development of modern Russia, international communism, American civilization, Afro-American and non-Western history, the Renaissance, imperialism, European thought, and twentieth-century thought. Methods of instruction are similarly varied and include formal lectures, class discussion, colloquia, films and tutorials leading to independent research by students.

ECONOMICS

The economics courses of the department guide students in developing a critical understanding of contemporary economic ideas and their roots, institutions and problems. They concentrate in posing, in their theoretical and historical context, the important questions of domestic and international public policy. Majors in economics will receive a thorough grounding in the tools of economic analysis, mathematics and statistical methods. Concentration in economics will therefore prepare students for careers in governmental service, business and graduate work not only in economics, but in any of the social sciences. Finally, this theoretical training is applied to actual economic problems and circumstances.

BEHAVIORAL SCIENCE

Introductory courses in anthropology, politics, sociology, psychology and social psychology are intended to broaden students' understanding of social process and human behavior and to prepare them to meet problems of a professional or administrative nature with insight and sophistication. For the student
A contemporary liberal arts core curriculum, representing a new vision of liberal education is available for students in the Bachelor of Science Degree programs in Social Sciences or the Humanities. For a full description, see section "Contemporary Liberal Arts Core Curriculum," page 99.

1SS 140-141 may be taken in place of SS 100 and SS 104. See the humanities and social sciences requirements on page 135.

2History and History of Science options may be combined.

MAJOR CONCENTRATIONS

(All courses are three credits each.)

History

SS 110 Renaissance and Reformation Era
SS 115 History of Africa
SS 116 History of Latin America
SS 120 History of Tsarist Russia to the Revolution
SS 121 History of the Soviet Union
SS 123 History of the United States: From Settlements to Reconstruction
SS 124 History of the United States: From Reconstruction to the Cold Wars
SS 125 American Radicalism and Reform
SS 126 Afro-American History
SS 127 American Economic History in the Industrial Era
SS 128 History of Jazz
SS 129 Growth of the United States Constitution
SS 130 The American Revolution
SS 132 Problems of American Foreign Policy
SS 144 Colloquium in the Intellectual History of Europe During the 19th-Century
SS 145 Colloquium in 20th-Century Thought
SS 147 Colloquium in Imperialism
SS 148 Colloquium in the History of Socialism and Communism
SS 149 Colloquium in the History of Marxism
SS 153 Revolutions in Comparative Historical Perspective
SS 154 Russia, China and the West
SS 179 Sociology of Human Disease
SS 622 Theory and History

History of Science and Technology

(SS 101-102 required)

SS 135 History of Science and Technology: Antiquity to Galileo
SS 136 History of Science and Technology: Galileo to Darwin
SS 137 History of Science and Technology: Faraday to the Present
SS 138 Technology, Science and Contemporary Society
SS 139 Technological Forecasting
SS 140 Science and Technology in America
SS 602 Seminar in the History of Science
SS 615 Guided Reading in the History of Ideas
SS 616 Guided Reading in the History of Science
SS 620 History of Biology
SS 621 Development of Physical Theory from Maxwell to Einstein
SS 622 Theory and History
SS 623 History of Technology: Antiquity through Early Industrial Revolution
SS 626 History of Technology: Industrial Revolution to the Present
SS 631 Seminar in the Sociology of Science
SS 635 History of Psychology

Behavioral Sciences

SS 139 Technological Forecasting
SS 157 Topics in Comparative Politics I
SS 158 Topics in Comparative Politics II
The Department of Social Sciences offers graduate courses in the history of science and technology, economics and psychology. These are intended for students majoring in social sciences and for graduate students in science and engineering interested in pursuing the interdisciplinary links between their own specialties and the social sciences. Outstanding students are advised to apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

History of Science and Technology—The master’s program in the history of science and technology was the first of its kind to be offered in the New York City area. The need for advanced study of the growth of science and technology and their interaction with human society and values has become increasingly evident. Intense specialization has further heightened the need for deeper understanding between the various branches of science and the humanities. In considering ideas, time, process, transfer and social change in the history of science, the student is afforded the opportunity of understanding the elusive connections that exist between science and engineering and the social sciences and humanities. Prospective teachers of science and engineering subjects will be able to increase their effectiveness through knowledge of the history of their own and related disciplines. Polytechnic’s libraries contain many important and rare works on the history of science that may be used for original research.

A total of 36 units is required for the master’s degree. Normally a student will start by taking the introductory courses, SS 600 and SS 601, and then proceed to the more advanced courses and seminars. But in each case the student’s program will be constructed in consultation with an adviser, taking into consideration the student’s background and interests. The student will be encouraged to take up to nine units of work in related fields outside the program, for example, philosophy, mathematical logic, Renaissance history or one of the sciences or engineering.

To qualify for the degree, the student may elect to write either a comprehensive examination or a thesis embodying an appropriate and substantive piece of research. If the student chooses the former, the examination may be taken in the term in which the course work is being completed. A student choosing the thesis may apply up to 12 units of course work toward the requirements for the degree. Acceptance of a thesis will involve an oral presentation and defense. In addition to the above requirements, the student must demonstrate a reading knowledge of one appropriate foreign language.

Environment — Behavior Studies — The master’s program in environment — behavior studies prepares the student for an interdisciplinary field, which combines efforts and expertise in behavioral and design professions. This program emphasizes the interaction between psychology and the various engineering
disciplines to fill a major gap in the training of professionals who work on applied socio-technical problems.

Many aspects of modern engineering and technological development have complex behavioral and social dimensions. Few professionals, however, are conversant with both the technical and social/behavioral aspects of a problem. This program is designed to produce graduates who have such interdisciplinary abilities by providing students who already have a background in the technical and engineering issues with course work and experience in environment-behavior studies.

Since, as a psychology program, this curriculum does not provide extensive technological training, students who possess an undergraduate degree in a technical or engineering field will be given preference for admission. Applicants with humanities or social science backgrounds will be considered, but may be required to supplement this program with remedial technical and scientific courses to provide the necessary prerequisites for program electives.

Each student will develop, in consultation with an adviser, an individual program consisting of 18 units of core courses plus 12 units of elective courses. This program will be designed to complement the students’ background, training and experience as well as their particular interests, and may include courses from a variety of Polytechnic departments in addition to the Environment – Behavior Studies Program and Department of Social Sciences.

These individual programs may be developed from three broad areas of emphasis:

A. Human Behavior and the Large Scale Environment. Programs may include study in behavioral and social aspects (architecture and interior design) of transportation planning and of energy use and planning.

B. Social Impact Assessment. This area will involve training in the nature of social response to environmental change, and methodology and use of social impact assessment in the broader context of environmental impact assessment.

C. Laboratory Research in Environmental Effects. Programs in this area may emphasize the use of laboratory techniques for analyses of the effects of various environmental stressors (i.e., noise, pollution, crowding) on human behavior.

Students will also be required to complete a master’s thesis in the area of interest and pass a comprehensive psychology examination. The thesis may involve field research which stems from practicum experiences.

This 36-unit program may be completed in one year by full-time students or in two to three years by part-time students.

### Core Courses (18 units)

- SS 908 Experimental Psychology I
- SS 909 Experimental Psychology II
- SS 920 Seminar in Psychology
- SS 926 Environmental Psychology
- MA 552 Applied Statistics I
- MA 553 Applied Statistics II

### Thesis (6 units)

- SS 997 Thesis for degree of Master of Science

### Electives (12 units)

**Environmental Psychology Elective.** One elective must be chosen from available environmental psychology courses:

- SS 913 Behavioral and Social Aspects of Environmental Psychology
- SS 924 Social Impact Assessment
- SS 928 Topics in Environmental Psychology

### Free Electives

These courses may be taken from a wide range of courses chosen from the psychology program or other departments in consultation with an adviser to fit an overall program.

### Advanced Psychology Courses

- SS 910 Learning Theory
- SS 911 Psychology of Language and Communication
- SS 912 Sensation and Perception
- SS 913 Physiological Psychology
- SS 914 Comparative Psychology

### Doctoral Minor Requirements—The department offers doctoral minors in economics, history of science and psychology. Normally such a minor would entail at least twelve units of course work in the respective field. In each case, however, the prospective student should obtain the sponsorship of a member of the faculty of the Department of Social Sciences and arrange a specific program.

### UNDERGRADUATE COURSES

#### HISTORY AND HISTORY OF SCIENCE AND TECHNOLOGY

- **SS 101 History of Western Civilization 1500-1815** 3:0:3
- **SS 102 History of Western Civilization 1815-1914** 3:0:3

Courses SS 101-102 provide an integrated introduction to the political institutions, theories and practices, economic organizations and techniques, scientific and technological accomplishments, religious and ethical beliefs, and the intellectual and artistic heritage of Western society between approximately 1500 and 1914. May be taken independently.

- **SS 104 Main Themes in Contemporary World History** 3:0:3

Major sources of change, transformation and tension in 20th century. Discussions, readings, lectures, films on war, racism, scientific-technical revolution, socialism, communism, imperialism, the U.S. and revolutionary movements, modernization of underdeveloped societies, cold war and current crises.
SS 144 Colloquium in Intellectual History of 19th-Century Europe* 3:0:3
Investigation of European thought and artistic and scientific tendencies against background of political, economic, social institutions and changes. Discussions of selected sources in politics, economics, science, the arts.

SS 145 Colloquium in Twentieth-Century Thought 3:0:3
Investigation of contemporary ideas of Europe and America. Reading and evaluation of selected works in political theory, economic theory, philosophy of science; historiography, ethics, aesthetics, mass cultures.

SS 147 Colloquium in Imperialism* 3:0:3
Study of principal theories of imperialism establishing (1) their premises, (2) their internal consistency, (3) their historical validity, especially in light of breakup of world empires since World War II. Course helps students establish their own criteria and judgments. Prerequisite: SS 104 or equivalent.

SS 148 Colloquium in The History of Socialism and Communism* 3:0:3
Socialist movement from founding of Second International to collapse in 1914 and revival in interwar years. Communist movement from theoretical controversies within social democracy before World War I to Eurocommunism. Examinations of socialist theories and ideologies, national parties, international organizations; interpretive materials and source in translation.

SS 149 Colloquium in the History of Marxism* 3:0:3

SS 151 Introduction to Politics* 3:0:3

SS 153 Revolutions in Comparative Historical Perspective* 3:0:3

SS 154 Russia, China, The West* 3:0:3

SS 157-158 Topics in Comparative Politics* each 3:0:3
Selected topics for analysis and research, including politics of advanced and emerging areas: party systems in United States, Soviet Union, People's Republic of China; National interests and conflicts in international relations; liberty and authority; pluralism and power; administrative web; judicial institutions.

SS 161 Society and Film 3:0:3
The film viewed as document and instrument of social structures and relations. The film as facet of mass culture and mass communication and as means of shaping and reflecting attitudes and values. Each of the following historically framed subjects constitutes a separate course for credit: Depression America—Fantasy & Reality, War: A Cross-Cultural Comparison, Weimar Germany in the Shadow of Fascism, Wartime Collapse of France—Genocide & Retrospect, Postwar Italy—the Politics of Sex—Anti-Clerical Revolution in the Third World Cold War America—Ego Affirmation & Nightmare; Soviet Images of Russia's Past Film screenings, readings, lectures and discussions. Lab required. May be repeated for credit.

BEHAVIORAL SCIENCE

SS 175 Introduction to Sociology 3:0:3
An elementary treatment of the influence of culture and social structure on human behavior. Topics include concepts of sociological analysis, types of human societies, social stratification, urban ecology, the social context of the environmental crisis, and the human impact of technology.

SS 177 Social Problems 3:0:3
Examination of social disorganization and deviant behavior in contemporary society. Investigation of specific problem areas: crime and juvenile delinquency, mental disorder, drug addiction, alcoholism, suicide, family disorganization, poverty and unemployment. Comparison with cultures of other peoples and/or simpler societies. Discussion of conflicting theories of causes for deviance and social disorganization.

SS 178 Minorities in the New World* 3:0:3
Historical, political, social and economic background to ethnic and race relations in United States and Latin America: Assimilationist, segregationist, pluralist policies; related attitudes. Position of Spanish-speaking minorities of Puerto Rico and Mexican descent in United States; compared with ethnic and racial relations in Puerto Rico, Cuba, Brazil.

SS 179 The Sociology of Human Disease* 3:0:3
The study of human disease in the context of social and biological adaptation. The disease "profiles" of the three major levels of man's social evolution, viz.: hunters and gatherers, low-energy agriculturists, and states are considered within a broadly conceived human ecological framework. Recommendations: some background in biology and anthropology is desired.

SS 180 Sociology and Urbanization* 3:0:3
Origin and history of urbanization, economy of contemporary cities and urban-rural relations, urbanism, family patterns, personality development. Urbanism, social-economic stratification, distribution of power, comparative analysis of urbanization in non-Western world. Student projects on urban problems.

SS 182 Man and the Environment 3:0:3
Development of broad ecological understanding of interaction of humans with non-human environment through survey of relevant topics: ecosystem, human interaction with ecosystem, human societies as self-regulating systems, attitudes toward nature, case studies in ecological history, present environmental crisis and attempts at resolution.

SS 185 Anthropology: Physical 3:0:3
The biosocial basis of human conduct seen in evolutionary perspective. The elementary genetic, demographic and ecological models necessary for the understanding of human behavior: biology as an evolutionary complex emerging from the primate revolution through the Neolithic revolution.
SS 196 Anthropology: Cultural
Social evolution from the hunting and gathering band through state society. A consideration of both variation and developmental trends in several human institutions such as kinship, economic organization, warfare, politics, religion and technology. Demographic and ecological variables receive primary stress.

SS 197 World Prehistory
World history from emergence of humans to development of early civilizations, introduction to archaeology, early man in old and new world patterns of migration, trade, rise of farming and sedentary life, development of civilizations in Mesopotamia, Egypt, China, India, Africa, Peru, Mexico, Guatemala.

SS 198 Social Change and Evolution
Theories of social change, evolutionary versus functionalist views. Evolution of social institutions through various stages of human history. Implications for solutions to contemporary social problems in both industrial societies and underdeveloped nations.

SS 199 Introduction to Psychology
Scientific study of behavior. Extensive treatment of basic areas of learning, physiological psychology, sensation systems with introduction to areas of developmental, educational, abnormal and social psychology. Lectures, class discussion, presentation of film, demonstrations of experiments.

SS 200 Environmental Psychology
The study of the way in which people use and are affected by their physical environments. Includes research in natural environments as well as built urban areas. Research on personal space, privacy, territoriality, crowding and design-behavior relationships. Students are involved in field research to assess the fit of environments to human needs, using interview techniques, behavioral observation and unobtrusive measures. Prerequisite: SS 199 or equivalent.

SS 201 Social Psychology
Study of behavior as function of social stimulation. Nature of sociopsychological inquiry, particular emphasis on experimental methods. Biological bases of social behavior, socialization processes, effects of social stimuli on perception and communication, group processes, attitude change, interpersonal bargaining. Student participation in experiments. Prerequisite: SS 199.

SS 202 Experimental Psychology I

SS 203 Experimental Psychology II
Complex learning and verbal behavior. Students design, carry out and analyze experiments dealing with such complex behavior as learning verbal responses, concept formation, communication nets, perform original experiment (designed with help of instructor). Laboratory reports required. Lectures on both substance and method of experiments. Prerequisite: SS 192.

SS 204 Drugs and Behavior
Mechanisms of action of various classes of drugs: tranquilizers, stimulants, analgesics, narcotics, hallucinogens. Discussion on neurophysiological and pharmacological basis of drug action and behavioral effects of different drugs. Economic, historical, political, sociological, anthropological aspects of drug use and abuse. Prerequisites: SS 199 and CM 105.

SS 205 Abnormal Psychology

SS 206 Stress and Relaxation
Behavioral, physiological and anatomical changes that result from stress and the relationship between stress and disease. Techniques of reducing stress and anxiety such as Jacobson's relaxation technique, meditation, yoga and biofeedback are examined. The laboratory gives the student the opportunity to measure the body's behavioral and physiological responses to stress and anxiety and to practice the relaxation techniques including yoga and biofeedback training. Prerequisite: SS 189.

SS 207 Personality Development
Methods of inquiry relevant to study of personality. Personality development in terms of social learning variables. Dynamics and structure of personality, personality change. Examples of personality research on variables: authoritarianism, need for achievement, self-concept. Prerequisite: SS 199.

SS 208 Psychology of Human Development
Course of human development from birth to old age with special emphasis on effects of age on thinking, learning, social behavior. Current research related to implications for teaching and educational programs. Prerequisite: SS 199.

SS 209 Organizational Behavior
Study of behavior in industrial settings. Emphasis on informal and formal group dynamics, interpersonal relationships, supervision, leadership, communication theory, attitude measurement, creativity. Analysis of administration problems by case studies and simulated situations. Prerequisite: SS 199.

SS 210 Psychology of Learning
Process of response acquisition and maintenance in human beings and other animals. Concepts of reinforcement, extinction, schedules of reinforcement, generalization, discrimination training. Relationship of learning to emotion and motivation. Transfer of training, retention and forgetting, concept learning, acquisition of skills. Theories of learning and application of learning to other areas of psychology. Prerequisite: SS 199.

SS 211 Cultural Backgrounds of African Nations
Introduction to precolonial history and cultures of Africa. Impact of colonialism, changing forms of political, economic and social organization. Emergence of nationalism, Pan Africanism, move-
SS 212 Cultural Backgrounds of Nations of Asia* 3:0:3
Ecological and cultural areas of Asia in relation to outline of Asian history. Origin and development of urban society in Middle East and expansion into China and India. Classical cultures of China, India, Southeast Asia. Relations with surrounding tribesmen. Impact of Western imperialism. Contemporary social, economic, political developments with concentration and student projects on selected countries.

SS 213 History and Culture of Americans Called Indians 3:0:3

ECONOMICS

SS 251 Microeconomics 3:0:3
Introduction to supply and demand analysis. The allocation of resources and distribution of income. Various market structures: perfect competition, imperfect competition, oligopoly and monopoly.

SS 252 Macroeconomics 3:0:3
Introduction to national income analysis. Employment, and unemployment, inflation and growth. The federal government and fiscal policy, the Federal Reserve Board and monetary policy.

SS 254 Economic Issues 3:0:3
Issues such as unemployment and inflation, urban fiscal crisis, racial and sexual discrimination, pollution, poverty, imperialism and military spending. Role of state in economy.

SS 255 The Contemporary American Economy: Boom and Bust 3:0:3

SS 257 History of Economic Thought* 3:0:3
Development of economic thought concentrating on various schools of thought that anticipated and prefigured modern economic analysis. Prerequisite: SS 252 or SS 254 or equivalent.

SS 258 Comparative Economic Systems* 3:0:3
Introduction to the concepts of history of economic systems: capitalism, socialism, the market and planning. Analysis of income distribution, resource allocation and modes of economic decision-making under different economic systems. Comparisons of centrally planned communist economies such as in the Soviet Union or Cuba, and the market-socialism of Yugoslavia with the regulated capitalist economy of the United States.

SS 259 Economic Development* 3:0:3
Consideration of theories of development for both advanced and underdeveloped economies. Different historical paths to development, problems of technological change, capital accumulation, economic planning.

SS 262 Collective Bargaining 3:0:3
Study of institutions of labor-management collective bargaining. Historical background, bases of power, day-to-day administration and bargaining. Intrusion bargaining, major substantive issues and problems, legislation, public policy implications, effects of technological progress, strike and its alternatives, comparison with other bargaining settings (e.g. international negotiations).

SS 263 Labor Economics* 3:0:3

SS 264 Urban Economics* 3:0:3
Contemporary American city and changing functions. Interaction of population with housing, jobs, transportation. Problems of public finance and services, land use, urban decay and renewal. Analytic tools to examine economic aspects and evaluate policy alternatives.

SS 265 Money and Banking* 3:0:3
Nature of money, gold and paper standards, commercial banks and Federal Reserve system, financial institutions, balance of payments, exchange rates, international monetary order. Money, prices, inflation, business fluctuations. Domestic and international monetary policy.

SS 266 Libertarian Economics* 3:0:3
Libertarian, free-market analysis of economy and government policy. Contrasts nature and consequences of government operation and intervention into economy with workings of the market. Alternative free market solutions examined for problems now met by political intervention.

INTERDISCIPLINARY

SS 300-301 Guided Readings in Social Sciences each 3:0:3
Selected problems in social sciences/history, economics, anthropology, sociology, psychology, politics, interdisciplinary studies. Individual or group projects under faculty supervision involving guided reading and/or research. For mature students of social sciences wishing to undertake specialized, independent study under tutorial guidance. Prerequisite: junior standing in social sciences or department’s permission.

SS 310 Women in Current Perspective 3:0:3
Psychology, anthropology, sociology of women and women’s movement. Emphasis on biological basis of sex role differentiation, sex role acquisition in cross-cultural perspective, societal allocation of roles. Women's movement—history and potential for change in current attitudes, lifestyles, the political and economic system.

SS 357 Technology Transfer to Developing Countries 3:0:3
Levels of technology: village, intermediate, advanced. Mechanisms of technology transfer to less developed countries. National and international means to stimulate or block transfer. Ecological, social, economic factors in technology selection and utilization. Technology and political influence. Case studies of recently industrializing nations. Also listed under IE 357 and MG 757

SS 358 Human Resources Development in Developing Countries 3:0:3
Spectrum of technology-related manpower needs in less developed countries. Education of engineers, technicians and skilled mechanics. Use of foreign personnel, foreign schools,
Seminar and study design.

SS 361: Special Topics in Social Sciences* each 3:0:3
SS 362: Special Topics in History* each 3:0:3
SS 363: Special Topics in History of Science and Technology* each 3:0:3
SS 364: Special Topics in Economics* each 3:0:3
SS 365: Special Topics in Psychology* each 3:0:3

SS 500-501: Social Sciences Theory and Method I, II* each 3:0:3

SS 502-503: Social Sciences Theory and Method III, IV* each 3:0:3
Seminar dealing with formulations of hypotheses and designing of research with methods for data collection and analysis specific to various social science disciplines. Practical experience in use of archival and other primary source materials, in formulation and analysis of questionnaire and in techniques of interviewing and observation. Evaluation of various methods in relation to types of problems raised. Relation between theoretical framework and study design. SS 502 prerequisite: SS 500-501. SS 503 prerequisite: SS 502.

GRADUATE COURSES

HISTORY OF SCIENCE AND TECHNOLOGY

SS 600*: History of Science and Technology: Antiquity to the Scientific Revolution 2:5:0:3
History of biological and physical sciences from antiquity to Renaissance. Intensive introduction to issues, aims and tools of historian of science working in this period.

SS 601*: History of Science and Technology: Scientific Revolution to Darwin 2:5:0:3
History of biological and physical sciences from scientific revolution to period of Darwin. Intensive introduction to issues, aims and tools of historian of science working in this period.

SS 602*: Seminar in History of Science 2:5:0:3
Advanced problems in history of science: development of quantification, historiography of science, history of ecology, science and social thought. Main topic chosen by students and instructor. Training in methods of archival research. Required regular reports leading to a major paper. Course may be taken twice for credit with different topical emphasis and permission of instructor.

SS 615*: Guided Reading in History of Ideas 2:5:0:3
Independent study of leading interpretative works and sources in intellectual history of Western civilization. Regular tutorial sessions and periodic staff-faculty colloquia. Course may be taken twice for credit with different topical emphasis and permission of instructor. Comprehensive written examination.

SS 616*: Guided Reading in History of Science 2:5:0:3
Independent study of leading interpretative works and sources in history of science. Regular tutorial sessions and periodic student-faculty colloquia. Course may be taken twice for credit with different topical emphasis and permission of instructor. Comprehensive written examination.

SS 620*: History of Biology* 2:5:0:3
Upper-level course with discussion of principal issues to which biologists have addressed themselves, solutions which they have offered, and relationships between these solutions and both the technical capacities of investigators and philosophical and other "sets" inherent in milieu of investigators.

SS 621*: Development of Physical Theory from Maxwell to Einstein* 2:5:0:3
Upper-level course investigating origin of knowledge that eventually led to criticism of Newtonian synthesis and attempts to find suitable, more general replacement.

SS 622*: Theory and History* 2:5:0:3
Advanced study of techniques and philosophy of historical writing with special reference to work of widely known historians: Burckhardt, Croce, Meinecke, Bloch, Namier, Beard, Toynbee, Huizinga, Sarton, Pierre.

SS 625*: History of Technology: Antiquity through Early Industrial Revolution 2:5:0:3
SS 626*: History of Technology: Industrial Revolution to the Present 2:5:0:3
These two courses involve detailed studies of the evolution of techniques and tools used in man's attempts to master environment. Introduction to reciprocal relationships between technology and other levels of society's economic and social structures, political policies, general cultural manifestations. Particular investigation of technological bases of historical change and interactions of science and technology. SS 625 prerequisite: SS 600 or equivalent. SS 626 prerequisite: SS 601 or equivalent.

SS 631* Seminar in Sociology of Science* 2:5:0:3
Materials and sources from sociology and history of science dealing with mutual interactions between science and society, professionalization and specialization, growth of scientific institutions, models of scientific growth, problems associated with social organization of science.

SS 635*: History of Psychology* 2:5:0:3
Survey of psychology against background of periods in which principal modern schools and issues emerged. Treatment of early psychology as speculative discipline, essentially part of philosophy, following with differentiation of psychology into various fields. Prerequisite: SS 189-190 or equivalent or SS 135-136 or equivalent.

SS 640-641*: Environmental Studies Seminar* 3:0:3
This seminar provides the opportunity to investigate environmental issues in-depth by focusing on a specific topic each year. The aim of the seminar is to cultivate a more holistic understanding of human societies in their ecological settings. Attention is given to such factors as weather, technology, population, social organization and political structure. Each student is responsible for a seminar paper. Guest participants on special topics. Prerequisite: SS 182 or other appropriate environment studies or permission of the instructor.
SS 672 Technological Forecasting  2½:0:3
Also listed under MG 672

SS 675† Technology Transfer to Developing Countries  2½:0:3
Levels of technology: village, intermediate, advanced. Mechanisms of technology transfer to less developed countries. National and international means to stimulate or block transfer. Ecological, social and economic factors in technology selection and utilization. Technology and political influence. Case studies of recently industrializing nations.
Also listed under IE 757 and MG 757

SS 676‡ Human Resource Development in Developing Countries  2½:0:3
Spectrum of technology-related manpower needs in less developed countries. Education of engineers, technicians and skilled mechanics. Use of foreign personnel, foreign schools, "brain-drain" problems. Economic consequences. Comparisons of educational systems of Western, Eastern and developing countries. Design of curricula to suit national needs. Role of technical assistance programs. Forecasting of human resource needs.
Also listed under IE 758 and MG 758

ECONOMICS

SS 700‡ Industrial Organization of American Economy*  2½:0:3
Measuring monopoly and competition in American economy. Effects of industrial structure on business performance—profit rates, output, etc., and business behavior—collusive practices, price discrimination, etc. Other economic and political implications of concentration. Antitrust and other governmental attempts at social control. Alternative theories of industrial organization. Available to undergraduate majors in social science. Prerequisite: instructor's permission.

SS 711 Advanced Economic Theory*  2½:0:3
Advanced microeconomy. Theory of utility and demand. Theory of prices and markets, profits, interest, capital, rent and wages. Monopoly and competition. Methodology of economics. Prerequisite: SS 251 or permission of the instructor.

SS 713‡ Econometric Models and Methods*  2½:0:3
Econometric models with and without stochastic formulation, principal component analysis, representation of economic phenomena, supply and demand, elementary Keynesian model, consumption function. Linear hypothesis and multiple regressions, linear models with errors in variables, time series analysis, autoregressive and distributed lag models. Simultaneous equation systems. Spectral methods in economics. Prerequisites: SS 251 or SS 252, and MA 092 or MA 232, or equivalent.

Also listed under MG 674 and IE 674

SS 720 Mathematical Economics*  2½:0:3
Contributions of mathematical analysis to traditional economic problems. Review of basic mathematical tools. Capital theory, economic growth, static equilibrium, individual behavior, welfare economics. Subject of special interest to students. Each topic approached in specific manner. Assumptions underlying (axiomatic to) models sought in empirical evidence. Given these assumptions, necessary consequences deduced with some rigor.

PSYCHOLOGY

SS 908† Experimental Psychology I*  2:3:3
An examination of the basic methodology of experimental psychology. Topics include research design, evaluation and treatment of experimental data. Psychophysics and scaling techniques, signal detection, simple and complex learning in both humans and animals. Prerequisites: SS 189, equivalent or permission of instructor.

SS 909† Experimental Psychology II*  2:3:3
The purpose of this course is to acquaint students with research methods, paradigms and procedures for laboratory and field research with human subjects. The substantive matter of the research covered will include social and environmental psychology. Students will be expected to perform research in laboratory and field settings using both experimental and quasi-experimental research designs. The emphasis of the course will be on developing research skills which can generalize to a wide variety of situations. Prerequisite: SS 908, equivalent or permission of instructor.

SS 910† Theories of Learning*  2½:0:3
Review of different theories of learning and associated experiments: application of theories to areas of programmed learning, behavior therapy, attitude function, social interaction. Each student required to perform one experiment on learning under guidance of instructor. Available to undergraduate majors in social science. Prerequisite: SS 189 or equivalent.

SS 911‡ Psychology of Language and Communication*  2½:0:3
Analysis of verbal behavior, including methodological problems in analysis of language, verbal behavior in animals, anatomical and physiological aspects of speech apparatus, operant and respondent conditioning of verbal behavior, semantics, statistical approaches and mathematical models, contextual factors. Pathology of speech. Each student required to do one experiment under guidance of instructor. Available to undergraduate majors in social science. Prerequisite: SS 189 or equivalent.

SS 912 Sensation and Perception*  2½:0:3
Review of different sensory systems: vision, audition, taste, smell, touch, temperature sensitivity, vestibular, kinesthetic senses, their relation to nonsensory controlling stimuli such as states of the organism, learning, social psychological variables. Techniques of obtaining psychophysical data on each sensory system and relation of sensory processes to theory of detection. Available to undergraduate majors in social science. Prerequisite: SS 189 or equivalent or instructor's permission.

Also listed under BE 675

SS 913 Physiological Psychology*  2½:0:3
Discussion of the physiological and anatomical bases of behavior. Topics such as memory, motivation, emotion, sleep, reward mechanisms, psychosurgery and higher cortical function are covered. Prerequisite: SS 189.

Also listed under BE 695

SS 914 Comparative Psychology*  2½:0:3
Comparison of behavior of different species as function of ethological and psychological variables. Behavior genetics, neural and hormonal control of behavior, behavioral consequences of special sensory structures, species specific behavior, development of behavior and concept of critical period, communication, and other social behavior and conditioning. Prerequisite: SS 189 or equivalent or instructor's permission.

Also listed under BE 676
SS 915 Behavioral and Societal Aspects of Transportation 2½:0:3
Behavioral analysis of transportation decision-making and travel characteristics. User needs in design of transportation systems including effects of such factors as crowding, social isolation, crime, comfort and convenience. Social impact of transport systems on communities. Prerequisite: undergraduate introductory psychology or MG 501 or equivalent. Also listed under MG 856 and TR 756.

SS 920 Proseminar in Psychology 2½:0:3
Intensive review of major areas in psychology required of all majors. Topics include history and systems, sensation and perception, learning, developmental and abnormal.

SS 924 Social Impact Assessment 2½:0:3
This course will be concerned with the way in which physical changes within urban or rural settings affect social systems and group and individual behavior. Issues to be discussed and considered include problems in measuring quality of life and social response to technology, and the use of alternative futures paradigms. Students will be expected to do an indepth analysis of a problem in social impact and report findings to the class.

SS 926 Environmental Psychology 2½:0:3
Readings and discussion on critical issues in person-environment relations, including privacy, crowding and environmental design. Course work will include a term paper and a major research project, emphasizing the application of psychological research methods to practical design problems or specific environmental issues.

SS 928 Advanced Topics in Environmental Psychology 2½:0:3
The subject matter of this course will vary from year to year depending on the needs and interests of both students and instructors. Potential subjects include: Social Impacts of Transportation Systems, Stress and the Environment,Adverse Environmental Factors, Laboratory in Animal Learning and the Effects of Pollution, The City—from a Psychological, Ecological and Historical Perspective, Applied Behavioral Analysis.

SS 935 Engineering Projects Related to Public Administration* each 3 units
See Cooperative Program with New York University's Graduate School of Public Administration for details.

SS 997 Thesis for Degree of Master of Science* each 3 units
Independent research project demonstrating scientific competence performed under guidance of adviser.

FACULTY

Kurt Salzinger, Professor of Psychology and Head of Social Sciences
B.A., New York University; A.M., Ph.D., Columbia University
Behavior theory and learning, abnormal psychology, language behavior

Marvin E. Settle, Professor of History
B.A., CCNY, M.A., Ph.D. The Johns Hopkins University
History of the United States, American constitutional history, nationalism, modern radicalism

Helmut Gruber, Professor of History
B.S. CCNY; M.A., Ph.D., Columbia University
History of socialism and communism, intellectual social and cultural history of 19th and 20th centuries, contemporary history

Thomas B. Settle, Professor of History
B.A., M.A., Ph.D., Cornell University
History of science, Galilean studies, history of biology

Frederick C. Kreiling, Professor of History
A.B., Hofstra College; A.M., Ph.D., New York University
History of science, environmental studies, music history

Murray N. Rothbard, Professor of Economics
A.B., M.A., Ph.D., Columbia University
Political and economic history, Austrian economics

Felix F. Strauss, Charles S. Baylis Professor of History
B.A., Hofstra College; M.A., Ph.D., Columbia University
Renaissance and reformation, entrepreneurial history, modern Central Europe

Lester O. Bumas, Associate Professor of Economics
B.B.E. CCNY; Ph.D., New York University
Labor economics, industrial relations, economic policy

Leonard Cohen, Associate Professor of Social Science
B.S., CCNY; M.S.L.S., Columbia University

Pamela E. Kramer, Associate Professor of Psychology
B.A., Bryn Mawr College; M.Ed., M.S., Tufts University; Ph.D., Yeshiva University
Psychology of women, developmental psychology, psycholinguistics

I. Leonard Leeb, Associate Professor of History
B.A., University of Pennsylvania; Ph.D., Columbia University
History of the Netherlands, colonialism and imperialism, history of political thought

Louis Menashe, Associate Professor of History
B.A., CCNY; M.A., Ph.D., New York University
Russian social history, revolutionary thought and politics, contemporary history

David Mermelstein, Associate Professor of Economics
B.A., Amherst College; Ph.D., Columbia University
Radical economics, current macroeconomic problems, comparative economic systems, urban fiscal problems
F. David Mulcahy, Associate Professor of Anthropology  
B.A., M.A., Ph.D., University of Massachusetts  
Marginal communities, human ecology, cultural symbolism  

Romualdas Sviedrys, Associate Professor of History of Technology  
B.A., Cornell University; Licenciada, Universidad Nacional (Columbia, S.A.); Ph.D., The Johns Hopkins University  
Technology forecasting and technology assessment, history of technology and science since 1750, technology and science in America  

Richard E. Wener, Visiting Assistant Professor of Psychology  
B.A., University of Wisconsin; M.S., Ph.D., University of Illinois, Chicago Circle  
Environmental psychology, crowding, clinical psychology  

ADJUNCT FACULTY  

Barbara Bienstock, Lecturer in Psychology  
B.A., Queens College  

Edward A. DeCarbo, Dean of Students and Lecturer in Anthropology  
B.S., F.S., Georgetown University; M.A., University of Chicago; M.A., Ph.D., Indiana University  

Steven J. Freimark, Assistant Professor  
B.S., M.S., Polytechnic Institute of Brooklyn; M.A., Queens College; Ph.D., SUNY (Stony Brook)  

Malcolm McCullough, Lecturer in Psychology  
B.S., Polytechnic Institute of New York  

James Moore, Lecturer in History and Economics  
B.A., M.A., University of Nebraska; Ph.D., SUNY (Stony Brook)
SYSTEM ENGINEERING

System engineering is based on the body of theoretical knowledge that underlies the engineering of modern complex systems. System engineering is the application of this body of knowledge to the design of systems, usually involving the integration of several disciplines to achieve the desired design objective. The theoretical resources of these fields include selections from among the newer branches of applied mathematics, methods for the analysis of signals and systems, the theories of communication and control, the techniques of optimization and of decision-making, and many of the facets of computer science.

Faced with a diverse and complex scientific environment, the system engineer may receive assignments crossing traditional lines of engineering applications. System engineering is presently applied in areas such as transportation, urban services, bioengineering, resource management, power and energy, and environmental and pollution control.

The course work in system engineering covers, in an interdisciplinary manner, the viewpoints, tools of analysis, and mathematical techniques of feedback control, instrumentation and measurement, analysis of data, optimization, communication of information, and simulation, stressing the use of analog and digital computers. The system engineering graduates' orientation and training enable them to participate in the analysis and solution of today's complex technological and societal problems.

The Department of Electrical Engineering and Computer Science administers the program leading to the degrees of master of science, engineer and doctor of philosophy in system engineering. Outstanding students should apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The entrance requirement for the master of science in system engineering is a bachelor's degree in engineering or science from an accredited institution, with a superior undergraduate record, including undergraduate courses in differential equations, probability, linear systems, feedback control and computer programming. Students with deficiencies in these areas may be admitted if they take appropriate introductory courses to remove these deficiencies.

To satisfy the requirements for the M.S. in system engineering degree, the student must complete a total of 36 units of courses, as described below, with an overall grade average of B. In addition, a B average is required in specific groups of courses, as indicated below.

Course Requirements

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<tr>
<th>Course Requirements</th>
<th>Units</th>
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<td>1. Three courses from among the following:</td>
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<td>EL 531 Probability</td>
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<td>EL 610 Linear Systems</td>
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<td>EL 611 Signals, Systems and Transforms</td>
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<td>EL 613 Applied Matrix Theory</td>
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<td>EL 621 Feedback Control I</td>
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<td>MA.661 Statistical Inference</td>
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</tr>
<tr>
<td>2. Two approved one-year sequences, which may include the above courses</td>
<td>6-12</td>
</tr>
<tr>
<td>3. Approved electives</td>
<td>21-15</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
</tr>
</tbody>
</table>

A complete course of study, including the choice of the one-year sequences, should be arranged in consultation with an adviser. A master's thesis of 9 units may be included as part of the elective courses. At least 24 of the 36 units must be in courses in engineering subjects, computer science or operations research.

An overall B average is required in the combination of five to seven courses offered to satisfy categories (1) and (2) in the above table.

The departmental Graduate Student Manual should be consulted for more detailed rules and procedures, including student status, recommended electives and one-year sequences, current areas of research and disqualification for low grades.

REQUIREMENTS FOR THE ENGINEER DEGREE

This post-master's professional degree is intended for engineers who desire to advance their professional development and training beyond the master's degree, by taking additional graduate courses and carrying out a substantial design project.

A candidate for the engineer in system engineering degree must have a program of study approved by an advisory committee. This program of study must contain a minimum of 72 units beyond the B.S. degree, and the candidate must have satisfied the requirements for a master's degree in system engineering.
In all other respects, the procedures and rules concerning this degree are identical to those for the engineer degree described in the electrical engineering section of this catalog.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

Graduate students who have demonstrated a high degree of scholastic proficiency and have given evidence of ability for conducting independent research may consider extending their studies toward the doctorate.

Admission to Program—Admission to the program is based on qualifying examinations, which a student usually takes after having completed one year of graduate studies. Successful completion of the master's requirements in system engineering should provide adequate course preparation for the examinations.

Specific requirements for this degree parallel those for the Ph.D. in electrical engineering as described elsewhere in this catalog and in the departmental Graduate Student Manual. These include course requirements, guidance committee formation, area examination, submission of the bound thesis, etc.

Qualifying Examinations—The format for these examinations is described in connection with the Ph.D. in electrical engineering. Principal areas of concentration for system engineering candidates are: communications, automatic control, computers and mathematical modeling and optimization. Current information about examination topics should be obtained from the doctoral adviser.

GRADUATE COURSES

SE 997 Thesis for Degree of Master of Science in System Engineering each 3 units Independent engineering project demonstrating professional maturity performed under guidance of advisor. Oral thesis defense and formal, bound thesis volume required. Registration of 9 units required; continuous thesis registration required. Prerequisite: degree candidacy.

SE 998 Project for Degree of Engineer in System Engineering each 3 units Comprehensive planning and design of engineering project under guidance of faculty adviser. Emphasis on up-to-date techniques. Oral examination and formal, bound report required. Scope of project is 6-12 units by prior agreement with adviser; continuous project registration required. Prerequisites: degree candidacy.

SE 999 Dissertation for Degree of Doctor of Philosophy in System Engineering each 3 units Original investigation of system engineering problem. Must demonstrate creativity and include features of originality and utility worthy of publication in recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required; continuous dissertation registration required. Registration beyond 12th unit requires passing of area examination. Prerequisites: degree candidacy and passing of qualifying examination.

PARTICIPATING FACULTY

Joseph J. Bongiorno, Jr., Professor of Electrical Engineering
Rudolf F. Drenick, Professor of System Engineering
Norbert Hauser, Professor of Industrial Engineering and Management Science
Wiener Helly, Professor of Operations Research
John H. K. Kao, Professor of Industrial Engineering
Frank Kozin, Professor of System Engineering
Frank J. Lupo, Professor of Electrical Engineering
William R. McShane, Professor of Transportation and System Engineering
Athanasios Papoulis, Professor of Electrical Engineering
Philip E. Sarachik, Professor of Electrical Engineering
Leonard G. Shaw, Professor of Electrical Engineering
Martin L. Shooman, Professor of Electrical Engineering and Computer Science
Joachim I. Weindling, Professor of Operations Research and System Engineering
Dante C. Youla, Professor of Electrical Engineering
Richard A. Haddad, Associate Professor of Electrical Engineering
Gerald Weiss, Associate Professor of Electrical Engineering
Christodoulos Chamzas, Assistant Professor of Electrical Engineering
TRANSPORTATION

The Department of Transportation Planning and Engineering offers programs leading to the degrees of master of science in transportation planning and engineering; master of science in transportation management; engineer in transportation engineering; and doctor of philosophy in transportation planning and engineering.

The students of transportation live in a boundless workshop in which they are able to experience first hand many of the problems involved in the movement of people and goods, both within and between congested urban areas. The facilities, regulations and controls which are discussed in the context of lectures and problems are on display in abundance in the activities of each passing day. Education in transportation is unique in the degree of feedback and personal involvement which the student experiences. This is a great asset in that virtually every student is familiar with the transportation medium.

Transportation is quite unlike many of the traditional engineering fields. In transportation, the professional works in a field which is intimately involved with human behavior and reactions. It is possible to compute the braking distance for a given physical situation, but each driver has a different reaction time. The transportation professional must, for example, discern and predict how people will travel, or desire to travel, at any given time. This involves the study and understanding of the basic factors that motivate people to travel and that motivate people to travel to particular places on particular modes of transportation. The prediction of transportation demand is complex, and because of the uncertainties of the human and economic elements, it is less precise than other engineering crafts, such as the resolution of stresses on a structure, in which all physical loads and conditions can often be precisely stated. The transportation engineer cannot provide positive control of transportation systems. The placement of a stop sign at an intersection does not guarantee that every vehicle approaching it stops. An air traffic controller can guide a pilot, but there are no fail-safe devices that can physically prevent a pilot from flying a plane improperly.

Transportation is then best described as the application of traditional planning, engineering and management approaches to the solution of problems involving strong human and economic elements. While all of the methods and techniques employed must be modified to account for this human element, the approach to problem investigation and solution is very much an engineering one. Transportation is a vital, living field for students to apply their efforts and is well suited to those having undergraduate degrees in engineering, economics, and/or science, as well as to many with backgrounds in the arts and social sciences. It is a broad field requiring an interdisciplinary approach for effective problem solving.

The primary goal of the academic program is to train transportation planners, engineers and managers who are able to plan, functionally design and control facilities and systems that are capable of satisfying the demand for transportation services, both passenger and freight. This is a challenging goal for the program, but it is the same challenge that must be met by every professional working in the field.

The program stresses the multi-modal approach to transportation and maintains strong curricula in highway and traffic engineering, public transportation, transportation planning, transportation safety, freight transportation, management and economics. The student is exposed to an atmosphere that provides a meaningful integration of practical and theoretical approaches. A combination of classroom presentations and practical problem solutions strengthens the overall education.

DEPARTMENT REQUIREMENTS

To be eligible for admission as a graduate student, an applicant must hold a baccalaureate degree or its equivalent from an acceptable institution. The department admits students with undergraduate degrees in engineering, the sciences, social sciences and the arts.

Students are expected to have an adequate background in mathematics, including probability and statistics. Students lacking a background in probability and statistics will be admitted but must take MA 551, Applied Statistics, in addition to other degree requirements. Credit toward a graduate degree will not be given for this course. Where additional background in mathematics is lacking, admission may be subject to the completion of specified undergraduate courses to make up the deficiency.

Students are expected to have basic skills in English that are adequate for the preparation of reports and papers. Such skills will be evaluated in appropriate courses together with technical material. All foreign students admitted to the department will be required to take an examination in English before their first registration. Based on the evaluation of that examination, they may be required to take one (in rare cases, two) additional courses in English as a second language for which no graduate credit will be given.
Grade requirements — to earn a graduate degree or certificate, Polytechnic regulations require that the student must have a 3.0 grade point average or better, in all graduate courses and a B or better average in all guided studies (readings, project, thesis, dissertation). Averages are separately computed for course work and guided studies.

In addition to Polytechnic grade requirements, the department requires an overall average of B or better in required courses taken toward a degree.

Registration Status

Students are admitted to the department in either degree, non-degree, or special status.

Degree Status — This status is assigned to applicants who apply for a degree program and whom the department feels are adequately prepared for and capable of such study. Students in degree status are expected to perform in a manner necessary to successfully complete the degree requirements with a B or better average. Students receiving one or more F grades, or students that are not performing with a B or better average will usually be placed either in non-degree status or on graduate probation.

Non-degree Status — This status is assigned to applicants who are asked to provide additional demonstration of their ability to pursue a graduate degree program. Students in non-degree status must obtain a B or better average for their first 12 units of course work and receive no F grades in order to be eligible for degree status. Non-degree students must fulfill these requirements for eligibility as degree students or be placed on graduate probation.

Special Status — Students who wish to enroll for one semester only for the purposes of taking one or more courses are generally admitted in this status.

Graduate Probation — Students placed on graduate probation may not register for further courses without the written permission of the department head and the concurrence of the Vice President for Research and Graduate Affairs. Such permission will include specific requirements to be met by the student in order to retain the right to register in subsequent semesters. Should such permission be granted, no student on graduate probation may register for more than 6 units in any semester.

The following courses are required of all students:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 600</td>
<td>Urban Transportation and Land Use Systems</td>
<td>3</td>
</tr>
<tr>
<td>TR 601</td>
<td>Travel Demand Forecasting</td>
<td>3</td>
</tr>
<tr>
<td>TR 629</td>
<td>Transportation Workshop</td>
<td>3</td>
</tr>
<tr>
<td>TR 701</td>
<td>Traffic Operations, Control and Management</td>
<td>3</td>
</tr>
<tr>
<td>TR 750</td>
<td>Transportation Economics</td>
<td>3</td>
</tr>
</tbody>
</table>

Students are expected to consult their advisers in selecting electives. Elective courses should be selected to provide the student with a cohesive body of knowledge in one or more areas of interest. The selection of electives is subject to the approval of the student's assigned adviser.

Elective courses are grouped into several key speciality areas. Students are generally advised to concentrate in one or two so as to develop an adequate depth of knowledge in areas of principal interest.

Electives in Transportation and Urban Planning

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 602</td>
<td>Urban Transportation Planning</td>
<td>3</td>
</tr>
<tr>
<td>TR 603</td>
<td>Computer Packages in Transportation &amp; Traffic Planning</td>
<td>3</td>
</tr>
<tr>
<td>TR 630</td>
<td>Urban Planning Principles</td>
<td>3</td>
</tr>
<tr>
<td>TR 653</td>
<td>Urban Land Use Planning</td>
<td>3</td>
</tr>
<tr>
<td>TR 640</td>
<td>Environmental Analysis of Transportation Projects</td>
<td>3</td>
</tr>
<tr>
<td>TR 641</td>
<td>Environmental Law and Technology</td>
<td>3</td>
</tr>
<tr>
<td>TR 660</td>
<td>Urban Public Transportation</td>
<td>3</td>
</tr>
</tbody>
</table>

Electives in Transportation Facility Design, Operation and Planning

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 660</td>
<td>Urban Public Transportation</td>
<td>3</td>
</tr>
<tr>
<td>TR 661</td>
<td>Intercity Passenger &amp; Freight Transportation</td>
<td>3</td>
</tr>
<tr>
<td>TR 665</td>
<td>Design of Rail Facilities</td>
<td>3</td>
</tr>
<tr>
<td>TR 670</td>
<td>Planning and Design of Terminals</td>
<td>3</td>
</tr>
<tr>
<td>TR 671</td>
<td>Airport Planning and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 672</td>
<td>Port Planning and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 715</td>
<td>Design of Traffic Facilities</td>
<td>3</td>
</tr>
<tr>
<td>TR 710</td>
<td>Urban Goods Movement</td>
<td>3</td>
</tr>
</tbody>
</table>

Electives in Highway and Traffic Engineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 702</td>
<td>Traffic Control Operations and Management II</td>
<td>3</td>
</tr>
<tr>
<td>TR 703</td>
<td>Traffic Studies</td>
<td>3</td>
</tr>
<tr>
<td>TR 704</td>
<td>Traffic Capacity and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 710</td>
<td>Design of Traffic Facilities</td>
<td>3</td>
</tr>
<tr>
<td>TR 720</td>
<td>Flexible Pavements: Design and Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>TR 721</td>
<td>Rigid Pavements: Design and Evaluation</td>
<td>3</td>
</tr>
<tr>
<td>TR 865</td>
<td>Highway Traffic Safety</td>
<td>3</td>
</tr>
</tbody>
</table>
Electives in Transportation Management and Economics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 661</td>
<td>Intercity Passenger and Freight Transportation</td>
<td>3</td>
</tr>
<tr>
<td>TR 751</td>
<td>Transportation Finance</td>
<td>3</td>
</tr>
<tr>
<td>TR 753</td>
<td>Management of Transportation &amp; Distribution Operations</td>
<td>3</td>
</tr>
<tr>
<td>TR 754</td>
<td>Logistics Analysis</td>
<td>3</td>
</tr>
<tr>
<td>TR 755</td>
<td>Legal &amp; Regulatory Aspects of Transportation</td>
<td>3</td>
</tr>
<tr>
<td>TR 757</td>
<td>Transportation Management</td>
<td>3</td>
</tr>
<tr>
<td>TR 759</td>
<td>Transportation Policy and Decision-Making</td>
<td>3</td>
</tr>
<tr>
<td>TR 750</td>
<td>Management of Transit Maintenance &amp; Operations</td>
<td>3</td>
</tr>
</tbody>
</table>

Electives in Special Areas of Transportation

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 830</td>
<td>Energy in the Transportation Sector</td>
<td>3</td>
</tr>
<tr>
<td>TR 845</td>
<td>Techniques in Transportation Analysis</td>
<td>3</td>
</tr>
<tr>
<td>TR 860/861</td>
<td>Selected Topics in Transportation I, II</td>
<td>3</td>
</tr>
<tr>
<td>TR 864</td>
<td>Transportation Safety</td>
<td>3</td>
</tr>
<tr>
<td>TR 855</td>
<td>Highway Traffic Safety</td>
<td>3</td>
</tr>
<tr>
<td>TR 856</td>
<td>Transportation System Safety</td>
<td>3</td>
</tr>
<tr>
<td>TR 898</td>
<td>Special Topics in Transportation for Developing Nations</td>
<td>3</td>
</tr>
</tbody>
</table>

Seminars and Guided Studies

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 901/902</td>
<td>Readings in Transportation I, II</td>
<td>3 ea.</td>
</tr>
<tr>
<td>TR 951/952</td>
<td>Seminar in Transportation I, II</td>
<td>0</td>
</tr>
<tr>
<td>TR 952</td>
<td>M.S. Project in Transportation Management</td>
<td>3</td>
</tr>
<tr>
<td>TR 956</td>
<td>M.S. Project in Transportation Management</td>
<td>3</td>
</tr>
<tr>
<td>TR 997</td>
<td>M.S. Thesis in Transportation</td>
<td>3 ea.</td>
</tr>
<tr>
<td>TR 998</td>
<td>Engineering Project in Transportation</td>
<td>3 ea.</td>
</tr>
<tr>
<td>TR 999</td>
<td>Dissertation</td>
<td>3 ea.</td>
</tr>
</tbody>
</table>

The residency requirement for the M.S. degree is 27 units, i.e., a minimum of 27 units of work must be taken at Polytechnic. The student may transfer up to 9 units of acceptable course work from other institutions subject to the department’s approval. Students may apply for transfer credit after they have completed 12 units of appropriate graduate courses at Polytechnic. To be eligible for transfer credit, the course in question must be relevant to the transportation program, and the student must have received a B or better in the course. Courses graded on a pass-fail basis will not be considered for transfer credit unless a detailed course evaluation from the instructor is provided. All transfer credit must be approved by an official transcript from the transferring institution.

In lieu of 6 transfer credits, the student may request validation of up to 6 units of graduate credit. To qualify for validation, the student must demonstrate an acquired knowledge or ability in an area covered by one of the courses offered by the department. The student is then examined in the area (by written and/or oral examination), and validation credit is awarded or denied on the basis of the examination. Students must pay a fee for each such examination. In no case may the total of transfer and validation credits exceed 9 units.

Requirements for the Master of Science Degree in Transportation Management

The field of transportation today encompasses not only the application of engineering approaches to transportation problems, but the management of the sundry private and public operators, planning agencies, consulting services and government departments that comprise the industry.

For those students whose goals lie in the management of technology rather than the direct planning and engineering of it in the transportation sector, this unique program provides graduate training specifically designed for their needs. The curriculum provides a mixture of management skills, knowledge of the transportation industry, and a core of specially designed courses in management and policy applications in the transportation field. Students emerge with a critical combination of skills preparing them for a managerial or policy level position in any sector of the transportation industry.

Transportation managers may find their field of application in a public agency, managing a planning, design or construction effort in an operating agency (such as a public or private transit operator) or for an airline or the shipping and trucking industries. The program emphasizes transit operations and goods distribution management, but provides basic skills applicable to all of the areas.

The program is intended to produce a graduate who has a thorough knowledge of the characteristics of transportation systems; the systems by which they are planned, built, and operated; and the ability to apply basic managerial principles to the optimizing of these systems.

The program is jointly administered by the Department of Transportation Planning and Engineering of the Division of Planning and Engineering and the Division of Management. It is a 36-unit program leading to the master of science degree.

The following courses are required of all students:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG 600</td>
<td>Management Process</td>
<td>3</td>
</tr>
<tr>
<td>MG 604</td>
<td>Managerial Accounting</td>
<td>3</td>
</tr>
<tr>
<td>TR 650</td>
<td>Urban Transportation and Land Use Systems</td>
<td>3</td>
</tr>
<tr>
<td>TR 751</td>
<td>Transportation Finance</td>
<td>3</td>
</tr>
<tr>
<td>TR 757</td>
<td>Transportation Management</td>
<td>3</td>
</tr>
<tr>
<td>TR 956</td>
<td>Project in Transportation Management</td>
<td>3</td>
</tr>
</tbody>
</table>

Total: 18 units
Students must select 12 units of electives from the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG 601</td>
<td>Organizational Behavior</td>
<td>3</td>
</tr>
<tr>
<td>MG 613</td>
<td>Industrial Relations</td>
<td>3</td>
</tr>
<tr>
<td>TR 750</td>
<td>Transportation Economics</td>
<td>3</td>
</tr>
<tr>
<td>TR 753</td>
<td>Management of Transportation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>and Distribution Operations</td>
<td></td>
</tr>
<tr>
<td>TR 754</td>
<td>Logistics Analysis</td>
<td>3</td>
</tr>
<tr>
<td>TR 755</td>
<td>Legal and Regulatory Aspects</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>of Transportation</td>
<td></td>
</tr>
<tr>
<td>TR 758</td>
<td>Transportation Policy and</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Decision-Making</td>
<td></td>
</tr>
<tr>
<td>TR 760</td>
<td>Management of Transit</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Maintenance and Operations</td>
<td></td>
</tr>
</tbody>
</table>

Students may complete their 36 units requirement by selecting 6 additional units from the above listing, or from among the graduate courses offered by the Department of Transportation Planning and Engineering or the Division of Management.

Residency requirements for the master of science (Program in Transportation Management) total 27 units. A maximum of 9 transfer units may be accepted subject to the same requirements stated for the M.S. (Transportation Planning and Engineering) degree. A maximum of 6 validation units may be requested in lieu of transfer units.

**REQUIREMENTS FOR THE ENGINEER DEGREE IN TRANSPORTATION ENGINEERING**

The engineer degree in transportation engineering is intended to be a terminal degree for those students wishing advanced practical education beyond the M.S. level. It requires 36 units beyond the M.S. degree.

The engineer degree program requires the following prerequisites for admission:

- an undergraduate degree in an engineering discipline from an accredited institution
- a master of science in transportation planning and engineering, or equivalent
- all required courses for the master of science in transportation planning and engineering, or their equivalent
- MA 551 or equivalent

A student lacking any of these must complete the prerequisites in addition to the degree requirements listed below. All students must complete the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 602</td>
<td>Urban Transportation Planning</td>
<td>3</td>
</tr>
<tr>
<td>TR 704</td>
<td>Traffic Capacity and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 998</td>
<td>Engineering Project in Transportation</td>
<td>6</td>
</tr>
</tbody>
</table>

| Total Units | 12 |

In certain cases an appropriate M.S. thesis (not project) or evidence of professional experience may be substituted for the engineering project, in which case 6 additional units of course work are required.

Students must select 18 units of electives from among the following courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 660</td>
<td>Urban Public Transportation</td>
<td>3</td>
</tr>
<tr>
<td>TR 665</td>
<td>Design of Rail Facilities</td>
<td>3</td>
</tr>
<tr>
<td>TR 670</td>
<td>Planning and Design of Terminals</td>
<td>3</td>
</tr>
<tr>
<td>TR 671</td>
<td>Airport Planning and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 672</td>
<td>Port Planning and Design</td>
<td>3</td>
</tr>
<tr>
<td>TR 702</td>
<td>Traffic Control, Operations,</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>and Management II</td>
<td></td>
</tr>
<tr>
<td>TR 703</td>
<td>Traffic Studies</td>
<td>3</td>
</tr>
<tr>
<td>TR 710</td>
<td>Design of Traffic Facilities</td>
<td>3</td>
</tr>
<tr>
<td>TR 715</td>
<td>Urban Goods Movement</td>
<td>3</td>
</tr>
<tr>
<td>TR 720</td>
<td>Flexible Pavements</td>
<td>3</td>
</tr>
<tr>
<td>TR 721</td>
<td>Rigid Pavements:</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Design and Evaluation</td>
<td></td>
</tr>
<tr>
<td>TR 845</td>
<td>Techniques in Transportation</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>TR 865</td>
<td>Highway Traffic Safety</td>
<td>3</td>
</tr>
</tbody>
</table>

Students complete their degree requirements with 6 units of free electives. If any required or elective courses listed above are taken as part of an M.S. program, additional free electives may be added in lieu of these. All free electives are subject to the approval of the student's academic adviser.

Residency requirements for the engineer degree are 27 units of study at Polytechnic. No more than 9 units of transfer and validation credit may be awarded toward this degree, with a maximum of 6 validation units.

**DOCTOR OF PHILOSOPHY DEGREE IN TRANSPORTATION PLANNING AND ENGINEERING**

The Ph.D. in transportation planning and engineering requires 90 units of graduate study beyond the bachelor's degree. The 90 units are made up of the following:

1. A 30-unit major in transportation planning and engineering, including all of the courses required for the M.S. degree.

2. Two 15-unit minors in related areas, one of which may be a specific area of focus within the transportation field.

3. A 30-unit dissertation, which must be an original piece of research that meaningfully advances the state-of-the-art in an area of transportation study.

It must be stressed that these are minimum requirements. Many students, particularly those entering with advanced degrees in other fields, may require additional course work in support of their dissertation development and to ensure passage of the Ph.D. qualifying examination described here. Applicants to the Ph.D. program are urged to make an appointment with a faculty adviser for individual consultation and recommendations.
Before being permitted to register for dissertation units, the candidate must pass a comprehensive Ph.D. qualifying examination. The examination is given once a year, usually in June, and consists of several written portions and an oral part. Copies of previous examinations are available on request from the department office to aid the student in preparation for this examination.

Students normally take the qualifying examination after their first year of full-time course work (or its part-time equivalent) is completed. All students who wish to take the examination are permitted to do so once they have been advised. Subsequent attempts are at the discretion of the department and in no case are more than three attempts permitted.

Ph.D. candidates must also qualify in one foreign language, which entails translation of a part of a technical book or article with the aid of a dictionary. Students whose native tongue is not English may qualify in English.

The residency requirement for the Ph.D. is 30 units, which must include the dissertation. Thus, a candidate is only required to complete the dissertation at Polytechnic to earn the degree here. Any and all course work taken at other institutions that is appropriate for either the major or minor may be transferred, provided they are of graduate level and a grade of B or better was achieved.

In support of dissertation research, a doctoral committee is formed to advise each student. Because of the interdisciplinary nature of transportation research, advisory committees include members of the faculty from many programs, as appropriate, including the following: mechanical and aerospace engineering, civil engineering, electrical engineering, management, mathematics, operations research, social sciences, transportation planning and engineering.

Once students register for dissertation units, they must meet several requirements. Dissertation registration must be continuous (minimum 3 units per semester, excluding summers) until work is completed. Leaves of absence must be formally requested from the Office of Graduate Affairs. Students must submit and orally defend a dissertation proposal before completing 6 units of dissertation registration. At the end of each semester of registration, students must submit a written progress report to their dissertation adviser. Upon completion, the dissertation must be presented and orally defended before the faculty. Consult the departmental bulletin, The Ph.D. Process in Transportation Planning and Engineering, for further details.

CERTIFICATE PROGRAMS

The department offers graduate certificates to students completing 15 units of course work in a concentrated subarea of transportation planning and engineering. Certificate programs are geared to students who do not wish to commit themselves to a full advanced degree program. These may be students with B.S. degrees who wish to specialize in one aspect of transportation, or those already holding advanced degrees who wish to develop an additional specialty and receive some formal certification for it. Students who enroll in certificate programs may apply for transfer to degree programs without loss of credits, assuming the courses taken are appropriate to the degree.

Transportation Planning and Engineering offers the following certificates:

<table>
<thead>
<tr>
<th>Traffic Engineering Certificate</th>
<th>Units</th>
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<tbody>
<tr>
<td>Required:</td>
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<tr>
<td>TR 701/702 Traffic Control Operations, and Management I, II</td>
<td>15</td>
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<tr>
<td>TR 703 Traffic Studies</td>
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<td>TR 704 Traffic Capacity and Design</td>
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<td>Plus 1 of:</td>
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<td>TR 710 Design of Traffic Facilities</td>
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<tr>
<td>TR 965 Highway Traffic Safety</td>
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Transportation Planning Certificate

Required:
TR 600 Urban Transportation and Land Use Systems
TR 601 Travel Demand Forecasting
TR 602 Urban Transportation Planning
TR 701 Traffic Control, Operations and Management I
Plus 1 of:
TR 603 Computer Packages in Transportation and Traffic Planning
TR 630 Urban Planning Principles
TR 845 Techniques in Transportation Analysis

Transportation Facility Design and Operation Certificate

Required:
TR 670 Planning and Design of Terminals
TR 671 Airport Planning and Design
TR 704 Traffic Capacity and Design
TR 710 Design of Traffic Facilities
Plus 1 of:
TR 665 Design of Rail Facilities
TR 672 Port Planning and Design

Public Transportation Certificate

Required:
TR 600 Urban Public Transportation
Plus 4 of:
TR 661 Intercity Passenger and Freight Transportation
TR 665 Design of Rail Facilities
TR 670 Planning and Design of Terminals
TR 671 Airport Planning and Design
TR 672 Port Planning and Design
TR 758 Transportation Policy and Decision-Making
TR 864 Transportation Safety
Transportation Management and Economics Certificate

Required:
MG 600 Management Process
TR 751 Transportation Finance
TR 757 Transportation Management
Plus 2 of:
TR 750 Transportation Economics
TR 753 Management of Transportation and Distributions Operations
TR 754 Logistics Analysis
TR 755 Legal and Regulatory Aspects of Transportation
TR 758 Transportation Policy and Decision-Making
TR 760 Management of Transit Maintenance and Operations

Units earned toward certificate programs are transferable to degree programs if they are applicable. No course, however, may be credited toward more than one certificate program.

ADVISING

In any graduate program, the relationship between the student and adviser is an important one. It is the academic adviser who will assist the student in selecting courses, and give guidance in all academic matters. The adviser also maintains a check on the student’s progress, and makes recommendations where problems arise.

Shortly after acceptance into the transportation program, each student is asked to select an area of special interest. This is in no way binding, nor does it commit the student to a particular course of study, but it does help us in the assignment of the most appropriate academic adviser in each case.

The students should meet with their adviser prior to each registration, and at any other time when they desire advice or consultation. The academic adviser must formally approve the student’s course selections prior to registration. The academic adviser also handles requests for waiver of certain degree requirements, such as required courses. Such waivers must be approved in writing by the academic adviser and the instructor of the required course, and must be entered into the student’s departmental file. When such waivers are granted, the student may be required to take another specific course in its place, or may be permitted to select an additional elective.

When a student registers for any guided study activity (readings, project, thesis, dissertation), he or she is also assigned an adviser for each such activity. This may or may not be the same as the academic adviser, depending upon the subject being studied. In order to register for a guided studies activity, the students must have submitted a written proposal of their topic to an appropriate adviser and have the adviser’s written approval. Doctoral students, in addition, are not permitted to register for dissertation until they have passed the Ph.D. Qualifying Examination.

Students studying under a research fellowship appointment will be assigned a research adviser, who is normally the principal investigator of the project which funds their fellowship. In some cases, the same faculty member will often act as the academic adviser. While the adviser’s function is to consult with and give advice to the student, it is the student’s responsibility to ensure that the requirements are fulfilled and submit all proper forms and applications when necessary.

UNDERGRADUATE COURSES

The department offers a limited number of undergraduate courses as electives for students in the various undergraduate programs at Polytechnic. These may not be taken for graduate credit by students of the Department of Transportation Planning and Engineering.

TR 360 Traffic Planning and Operations 3:0:3
An introductory course in the development and use of traffic engineering techniques to aid in the planning, functional design and control of highway and street systems. Includes traffic studies, accident analysis, capacity analysis, sign coordination, etc. Emphasis on practical applications. Prerequisite: junior status.

TR 361 Transportation Models 3:0:3
Introductory course in modeling for transportation planning and engineering. Emphasis on planning process and public transit modeling of travel demand, route selection and system evaluation. Emphasis on model building and applications. Prerequisite: junior status.

TR 362 Public Transportation Technology and Operations 3:0:3
Public transportation systems, their design and operation. Physical and hardware considerations such as rail vehicles, station design control systems. Service characteristics: express bus, local bus, commuter rail, rapid transit, demand actuated transit, etc. Operational and planning aspects: scheduling, fares structure and fare collection systems. Prerequisite: junior status.

GRADUATE COURSES

Graduate courses are grouped into major specialty areas of transportation. These groupings are intended to aid students in their course selection, which is subject to the approval of the academic adviser.

TRANSPORTATION PLANNING

TR 600 Urban Transportation and Land Use Systems 2:4:0:3
An overview of fundamental relationships between transportation supply, land development, and travel in urban areas; characteristics of urban transportation systems and their usage by people and goods; introduction to the theory and methods of regional and bi-regional forecasting of urban activities.
TR 601 Travel Demand Forecasting 2½:0:3
Theory and applications of travel forecasting methods to predict the amount and nature of travel on transportation systems. Emphasis on UMTA Transportation Planning System models. Corequisites: MA 551, TR 600, or equivalents.
Also listed under CE 894

TR 652 Urban Transportation Planning 2½:0:3
The course is structured to provide a comprehensive treatment of transportation system planning from the regional to the local level. Problem identification, issues and needs related to the planning, design and operations of transportation systems. Evaluation of transportation system performance and impacts. Prerequisite: TR 601 or equivalent.

TR 653 Computer Packages in Transportation and Traffic Planning 2½:0:3
The course introduces the student to a range of computer programs available for use in transportation and traffic planning. Major emphasis is given to understanding the capabilities of the FHWA and UMTA (UTPS) computer packages, which are widely used, as well as NETSIM and SPSS Microcomputer applications in traffic engineering are also presented. Students are introduced to these tools through computer-based problem solving as well as manual solutions, where practical. Prerequisite: TR 601 and TR 701 or equivalent.

TR 659 Transportation Workshop 0:5:3
Comprehensive projects utilizing basic fundamentals from courses taken or concurrently taken in the M.S. program. Projects assigned on an individual or team basis, depending on the scope. Principles and methods of technical report writing. Prerequisites: TR 601 and TR 701 or equivalents.

URBAN AND REGIONAL PLANNING

TR 630 Principles of Urban and Regional Planning 2½:0:3
A survey of the contemporary theory and methods of the planning function.
Also listed under CE 810

TR 633 Urban Land Use Planning 2½:0:3
A detailed treatment of land use planning and its interactions with the transportation planning process; relationships between land use patterns and travel demand, objectives and methods of land use planning; zoning and other implementation measures. Prerequisite: TR 630 or advisor's approval.

TR 640 Environmental Analysis of Transportation Projects 2½:0:3
Methods and practices for forecasting, identifying, measuring, analyzing and preventing or tempering the impacts of effects of transportation and other facilities, including air, noise, water and other ecological impacts, as well as community, psychological and other social impacts.

TR 641 Environmental Law and Technology 2½:0:3
Investigation of current crises involving the environment and its relationship to transportation technology. Subject matter has been specially developed to cover case law, legislative history, and economic and political issues concerning technology and the environment. Subjects of study include land use planning, conservation of aesthetics, regional control, transportation and related pollution of all forms. Student projects shall be required. Prerequisite: advisor's approval.
Jointly offered with Brooklyn Law School.

PUBLIC TRANSPORTATION PLANNING, OPERATIONS AND TECHNOLOGY

TR 660 Urban Public Transportation 2½:0:3

TR 661 Intercity Passenger and Freight Transportation 2½:0:3
Review of past and present operations, financial position and transportation role of each of the intercity passenger and freight modes in the United States, with foreign comparisons. History of each mode is presented, including the economic, technological and political factors that caused these modes to prosper (and decline). The role of government regulatory and fiscal agencies. Economic efficiency of government actions, the methods of "shared cost" estimation and related rate setting, and intra- and intermodal competitive forces are analyzed.

TR 665 Design of Rail Facilities 2½:0:3
The course deals with the design of systems for moving passengers and freight on rails. It involves roadbed, track, alignment, yards, station, signals communications and protection devices. The course also devotes several lectures to design of light-rail transit facilities.

TR 670 Planning and Design of Terminals 2½:0:3
An introductory course of passenger and freight terminals with emphasis on the system description of these facilities. Land, marine and air terminals are discussed. Methods are discussed for determining the level of service for pedestrian flow. TOFC and truck terminals are also covered.
Also listed under CE 840

TR 671 Airport Planning and Design 2½:0:3
Techniques for forecasting air passenger traffic, aircraft operations at commercial and general aviation facilities. Principles and practices for the planning and design of terminal facilities, ground transportation system, parking facilities, runways and navigational aids. Airport site selection, configuration and economics.
Also listed under CE 871

TR 672 Port Planning and Design 2½:0:3
The planning of marine terminal facilities for freight and passengers is an integral part of the transportation infrastructure, and is dealt with in detail; harbor and port capacity analysis, functional design and control of ports. U.S. port terminal needs for containers and bulk freight, port operations.

HIGHWAY AND TRAFFIC ENGINEERING

TR 701 Traffic Control, Operations and Management 1 2½:0:3
The traffic stream is comprised of automobiles, commercial vehicles, buses, pedestrians and other elements. The operation and control of this stream is treated on two levels: (1) overall articulation—Transportation Systems Management (TSM) and (2) the specifics of each component user and facility interactions, arterials, networks, freeways and traffic corridors are considered. Signal timing and coordination, oversaturated control, detectorization and computer applications are taught.
TR 702 Traffic Control, Operations and Management II 2 1/2:0:3
A detailed treatment of specific methods and experiences in controlling/managing several facility types, set in the context of current traffic problems and measures of effectiveness; computer control of networks and freeways, network decom­position, computer-based methods of analysis (SOAP, CMA, TRANSIT, FREEQ), traffic simulation and case studies; methods for reducing demand. Prerequisite: TR 711 or equivalent.

TR 703 Traffic Studies 2 1/2:0:3
Techniques for collection of traffic data and information: speed, travel time, volume, origin-destination, parking, accidents, etc. Analysis and interpretation of results: Corrective actions and program formulation based on study results. Also listed under CE 805

TR 704 Traffic Capacity and Design 2 1/2:0:3
The use of highway capacity analysis techniques in design, planning and operational analysis is treated. Highway Capacity Manual methods as well as foreign techniques and recent research developments are discussed and illustrated. Functional design of freeways, arterials, streets and rural highways is covered. Also listed under CE 806

TR 710 Design of Traffic Facilities 2 1/2:0:3
Presents functional and preliminary design principles and analyses for freeways and arterials; interchange design for freeway facilities and design of at-grade intersections; using principles of channelization. Design of parking garages and parking lots. Also listed under CE 821

TR 715 Urban Goods Movement 2 1/2:0:3
A description of urban goods movement, primarily by truck, and its effect on urban mobility. Includes regulatory and institutional framework, freight demand modeling, spatial requirements at terminals and in the urban area, rail and marine terminals, and the terminal/street interface. Also listed under CE 821

TR 720 Flexible Pavements: Design and Evaluation 2:1:3
Design and construction of flexible highway pavements, including road-mix, plant-mix and high-type bituminous pavements. Pavement performance and evaluation. Laboratory tests of bituminous materials and mixtures; Marshall, Hubbard-Field and Hveem stability tests. Viscosity of capillary viscometers. Prerequisite: CE 351 or equivalent. Also listed under CE 801

TR 721 Rigid Pavements: Design and Evaluation 2:1:3
Design and construction of rigid and airport pavements. Pavement performance and evaluation. Laboratory tests of plain and reinforced concrete pavements. Nondestructive testing techniques. Prerequisite: CE 351 and CE 252 or equivalent. Also listed under CE 802

TR 750 Transportation Economics 2 1/2:0:3
A brief review of the principles and concepts of engineering economics analysis and a thorough application of these principles to decision-making in the transportation sector; methods for estimation of capital, operating and direct-user costs in transportation, benefit concepts and estimation of benefits, indirect effects, transportation finance and taxation concepts of public finance and equity in taxation. Also listed under CE 812

TR 751 Transportation Finance 2 1/2:0:3
Material is approached from a public finance perspective, including a review of those economic theories and analytical techniques that are of particular rele­vance to transportation. Special attention is given to such areas as (a) the equity vs. efficiency question in transport finance (b) general vs. user-marked revenue methods (c) the valid (and invalid) use of cost-benefit and cost-effectiveness studies and (d) peak load (marginal cost) pricing. Also listed under MG 853

TR 753 Management of Transportation and Distribution Operations 2 1/2:0:3
Management of transportation carriers, including passenger and freight operations; physical distribution management within these industries; basic organization; rate structure analysis; equipment management; marketing of services; labor issues; corporate policy in a changing regulatory environment; analysis of logistics costs and the use of logistic system models. CoPrerequisite: TR 757 or equivalent.

TR 754 Logistics Analysis 2 1/2:0:3
The basic principles of logistics costs and analysis; interactions to physical distribution aspects of the shipper (packaging, materials handling, inventory) and warehouse management, plant and warehouse location, and related logistical analysis approaches. Prerequisite: TR 753 or adviser's approval.

TR 755 Legal and Regulatory Aspects of Transportation 2 1/2:0:3
An in-depth treatment of the origins, causes and effects of regulation on transportation and society in the U.S. Economic and constitutional basis for transportation regulation. The legal basis, structure and function of federal, state and local regulatory bodies and their interaction with transportation industries. Current controversies concerning the deregulation of sectors of the transportation industry. Also listed under MG 852

TR 757 Transportation Management 2 1/2:0:3
Management problems in the transportation sector; discussion of various types and forms of transportation organizations—planning organizations, operators, consulting firms, etc.—and treatment of organizational problems unique to each. Private vs. public transportation operators and agencies. Public authorities: legal basis, structure, purpose. Private shipping operations. Also listed under MG 857

TR 758 Transportation Policy and Decision-Making 2 1/2:0:3
A high-level treatment of policy formulation and decision-making in the transportation industry on several levels: federal, state and local policy, individual operating policies. Course uses an intensive case-study approach in a seminar or discussion format. Emphasis is on mass transit operations. Prerequisite: adviser's approval. Also listed under MG 858

TR 760 Management of Transit Maintenance and Operations 2 1/2:0:3
A basic treatment of management of functional transit system aspects, including design and monitoring of maintenance functions to provide a viable operating fleet and right-of-way, and the management of daily operations, including scheduling, run-cutting, dispatching and street management.
TRANSPORTATION SAFETY
AND OTHER SPECIAL TOPICS

TR 830 Energy in the Transportation Sector 2\%:0:3
Transportation consumes about 25 percent of all energy. It is necessary to consider the variety of sources, transportation modes and travel needs. Total energy, not just propulsion energy, is addressed. Three prime areas are the motor vehicle programs and policies, and public transportation. Technology, costs and interactions are noted. Developing engines, motors, alternative fuels and the electric vehicle are reviewed. Transport of energy itself is studied.

TR 845 Techniques in Transportation Analysis 2\%:0:3
Analytic techniques are introduced on three levels: (1) basic concepts, (2) case studies and (3) review of literature. Material covered includes: survey design and interpretation, use of simulators in transportation, construction and use of deterministic models for insight, statistical models, introduction to queuing and linear programming, introduction to Delphi technique and cost-utility. Course emphasizes the modeling concept and its application. Prerequisite: MA 551 or equivalent.

TR 860-861 Selected Topics in Transportation I, II each 2\%:0:3
These courses are utilized for the periodic presentation of topical material of current interest. Some recent topics presented as Selected Topics courses are: decision-making in transportation, computer packages in transportation, transportation systems safety and others. Some of these have been added to the regular curriculum because of their popularity as Selected Topics offerings. Prerequisite: advisor's approval.

TR 864 Transportation Safety 2\%:0:3
Comparative review of history and current practices in safety of all transportation modes: land, sea and air. Development of government participation and regulation. Analysis of related approaches in differing modes for reducing accidents and attenuating accident effects; lessons to be learned with applications from one mode to another. Safety promotion and educational activities. The economics of safety.

TR 865 Highway Traffic Safety 2\%:0:3
Methods used in the achievement of lower levels of highway traffic accident occurrence and accident severity, with concentration on proved, practical approaches based on sound engineering principles. Application of principles to real-life situations. Corequisite: TR 701 or equivalent.

TR 868 Special Topics in Transportation for Developing Nations 2\%:0:3
This special topics offering will cover topical issues in transportation for developing economies. Possible topics include: transportation planning for economic development; financing international transportation projects design and construction of low-type roadways, management of multinational project efforts and others.

GUIDED STUDIES

TR 901-902 Readings in Transportation 2\%:0:3
Study of special problems in transportation under the direct supervision of one or more members of the faculty. Prerequisite: advisor's approval.

TR 951-952 Seminar in Transportation I, II each 2\%:0:3
Presentations by guest speakers on relevant topics in transportation. Presentations and discussion of ongoing research by course participants and faculty. Required of all full-time degree students in the program. Prerequisite: advisor's approval.

TR 962 Master's Project or Internship in Transportation each 3 units
An independent project, or internship with a relevant transportation agency, leading to a report demonstrating the student's professional competence. Students are examined orally and must submit an acceptable written report (unbound). Prerequisites: degree status and advisor's approval.

TR 966 Master's Project in Transportation Management each 3 units
An independent project leading to a comprehensive report demonstrating professional competence in transportation management. Projects must be orally defended and be submitted in written (unbound) form. Prerequisites: degree status and advisor's approval.

TR 997 Thesis for the Degree of Master of Science each 3 units
Continuation of project work, initiated in TR 965, or original research of sufficient comprehensiveness for properly motivated students. Prerequisites: degree status and advisor's approval.

TR 998 Engineering Project each 3 units
A comprehensive individual project, usually in the form of a comprehensive engineering study and analysis, a functional design project or control/operations system design. Prerequisites: degree status and advisor's approval.

TR 999 Dissertation for the Degree of Doctor of Philosophy each 3 units
An original investigation embodying the results of comprehensive research in a specific area of transportation. Dissertation must be worthy of publication in a recognized scientific or engineering journal. The student is required to take an oral examination of the subject of the dissertation and on related topics. Prerequisites: degree status, passage of Ph.D. qualifying examination and advisor's approval.

FACULTY

William R. McShane, Professor of Transportation and System Engineering, Head, Department of Transportation Planning and Engineering, Director, Transportation Training and Research Center, B.E., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Transportation models, traffic control and operations, transportation systems management, transportation noise, computer applications, transportation and energy

William S. Allison, Professor of Transportation Management A.B., Williams College; M.B.A., Harvard University
Transportation management, transportation finance

Edmund J. Cantilli, Professor of Transportation Planning B.A., B.S.C.E., Columbia University, Cert. in Highway Traffic Engineering, Yale University; Ph.D., Polytechnic Institute of Brooklyn
Transportation safety, environmental impacts of transportation, urban planning, pedestrian and bicycle planning
John C. Falcocchio, Professor of Transportation Engineering; Director, Transportation Management Program
B.S.C.E., M.S., Ph.D., Polytechnic Institute of Brooklyn
Transportation planning, public transportation, transportation of disadvantaged groups

Louis J. Pignataro, Professor of Transportation Engineering
B.C.E., Polytechnic Institute of Brooklyn; M.S., Columbia University; Dr. Tech.S., Technical University of Graz (Austria)
Traffic engineering, transportation economics, public transportation, transportation and energy

Rogers P. Roess, Professor of Transportation Engineering and Associate Dean of Engineering
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn
Traffic capacity and design, public transportation, transportation economics, traffic engineering

Philip A. Habib, Associate Professor of Transportation Engineering; Administrative Officer
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Goods movement, highway design, highway planning, transportation planning, terminal planning, traffic engineering

Athanassios Bladikas, Assistant Professor of Transportation Management
B.S., CCNY; M.B.A., Columbia, Ph.D., Polytechnic Institute of New York
Transportation distribution, management, regulation, systems analysis, economic impacts

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ADJUNCT FACULTY

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Walter H. Kraft, Adjunct Professor
B.S., M.S., Newark College of Engineering; Dr.Eng.Sc., New Jersey Institute of Technology

Albert T. Roselli, Adjunct Professor
B.C.E., CCNY

William H. Crowell, Lecturer
B.S., Boston College; M.A., Ph.D., New York University

Paul J. Menaker, Lecturer
B.S., M.S., Ph.D., Polytechnic Institute of New York

Gennaro E. Sansone, Lecturer
B.S.E.E., Kansas State University; M.B.A., Iona College
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Brian Amerink, B.A., Assistant Director of Financial Aid

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Irene Dziezak, M.A., Associate Director of Career Services and Cooperative Education
Michele E. Stewart, B.A., Coordinator, Part-Time Job Development
L. Kay Griffith, B.A., Coordinator, Cooperative Education

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Hana Stanek, M.L.S., Reference Librarian
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Brooklyn Campus
Jeanette Grill, B.A., Program Coordinator, Long Island Center

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Ellen Reznik, Manager, Special Projects
J.V. Costabile, B.A., Director of Data Processing Services
John Denler, M.B.A., Personnel Officer
Thom Ford, M.A., Comptroller
Robert Hawks, M.A., Budget Director
Ronald Kusmier, M.P.A., M.S.W., Director of Administrative Systems

Admissions
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