ACADEMIC CALENDAR
1986-1987

FALL
- Monday, September 1, 1986 — Labor Day
- Tuesday, Wednesday, Thursday, Friday, September 2-5, 1986 — Registration
- Tuesday, September 9, 1986 — CLASSES BEGIN
- Monday, October 13, 1986 — No classes (Yom Kippur)
- Thursday, Friday, November 27, 28, 1986 — Thanksgiving recess
- Tuesday, December 9, 1986 — Monday classes meet
- Wednesday, December 10, 1986 — Friday classes meet
- Thursday, December 11, 1986 — CLASSES END
- Friday, December 12, 1986 — Reading day

RECESS
- Wednesday, December 24, 1986 — Thursday, January 1, 1987

INTERSESSION
- Friday, January 2 — Thursday, January 15, 1987

SPRING
- Tuesday, January 20 — Thursday, January 22, 1987 — Registration
- Monday, January 26, 1987 — CLASSES BEGIN
- Monday, April 13 — Friday, April 17, 1987 — Spring recess
- Friday, May 1, 1987 — CLASSES END
- Monday, Tuesday, May 4, 5, 1987 — Reading days
- Wednesday, May 6 — Thursday, May 14, 1987 — Final Exams
- Commencement — Monday, June 1, 1987

INTERSESSION
- Friday, May 15 — Tuesday, May 26, 1987

SUMMER
- Wednesday, Thursday, May 27, 28, Tuesday, June 2, 1987 — Registration
- Thursday, June 4, 1987 — CLASSES BEGIN
- Monday, July 5, 1987 — No classes
- Friday, July 17, 1987 — Monday classes meet
- Wednesday, August 26, 1987 — CLASSES END

1987-1988

FALL
- Tuesday, Wednesday, Thursday, Sept. 1, 2, 3, 1987 — Registration
- Monday, Sept. 7, 1987 — Labor Day
- Tuesday, Sept. 8, 1987 — CLASSES BEGIN
- Wednesday, Sept. 23, 1987 — No evening classes after 6 P.M.
- Thursday, Sept. 24, 1987 — No classes (Rosh Hashanah)
- Tuesday, Nov. 24, 1987 — Thursday classes meet
- Thursday, Friday, Nov. 26, 1987 — Thanksgiving recess
- Wednesday, Dec. 9, 1987 — Evening classes only meet
- Friday, Dec. 11, 1987 — CLASSES END
- Monday, Dec. 14, 1987 — Reading day

RECESS
- Thursday, Dec. 24, 1987 — Friday, Jan. 1, 1988

INTERSESSION
- Monday, Jan. 4 — Tuesday, Jan. 19, 1988

SPRING
- Wednesday, Thursday, Friday, Jan. 20, 21, 22, 1988 — Registration
- Wednesday, Jan. 27, 1988 — CLASSES BEGIN
- Monday, Mar. 28 — Friday, Apr. 1, 1988 — Spring recess
- Tuesday, May 3, 1988 — CLASSES END
- Wednesday, Thursday, May 4, 5, 1988 — Reading days
- Friday, May 6 — Monday, May 16, 1988 — Final Exams
- Commencement — Date to be announced.

INTERSESSION
- Tuesday, May 17 — Friday, May 27, 1988

SUMMER
- Wednesday, Thursday, May 25, 26, 1988 — Registration
- Tuesday, May 31, 1988 — CLASSES BEGIN
- Monday, July 4, 1988 — No classes
- Tuesday, July 12, 1988 — Monday classes meet
- Tuesday, Aug. 23, 1988 — CLASSES END

1988-1989

FALL
- Wednesday, Thursday, August 31, September 1, 1988 — Registration
- Wednesday, September 7, 1988 — CLASSES BEGIN
- Monday, September 12, 1988 — No classes (Rosh Hashanah)
- Tuesday, September 20, 1988 — No evening classes after 6 p.m.
- Wednesday, September 21, 1988 — No classes (Yom Kippur)
- Thursday, Friday, November 24, 25 — Thanksgiving recess
- Tuesday, December 13, 1988 — Evening classes only meet. CLASSES END.
- Wednesday, December 14, 1988 — Reading Day
- Thursday, December 15 — Friday, December 23, 1988 — Final Exams.

RECESS
- Monday, December 26 — Friday, December 30, 1988

INTERSESSION
- Monday, January 2 — Friday, January 20, 1989

SPRING
- Monday, Tuesday, Wednesday, January 23, 24, 25, 1989 — Registration
- Monday, January 30, 1989 — CLASSES BEGIN
- Monday, April 17 — Friday, April 21, 1989 — Spring recess
- Friday, May 5, 1989 — CLASSES END
- Monday, Tuesday, May 8, 9, 1989 — Reading Days
- Wednesday, May 10 — Thursday, May 18 — Final Exams
- Commencement: To be announced.

INTERSESSION
- Friday, May 19 — Tuesday, May 30, 1989

SUMMER
- Wednesday, Thursday, May 31, June 1, 1989 — Registration
- Monday, June 5, 1989 — CLASSES BEGIN
- Tuesday, July 4, 1989 — No classes
- Monday, July 17, 1989 — Monday classes meet
- Monday, August 28, 1989 — CLASSES END
Polytechnic University is the leading technological institution in the New York metropolitan region. Its mission is to address basic scientific theory and applications of technology, management of technology, and relationships between social institutions and technology through undergraduate, graduate, and continuing professional education and through an active and varied research program.

Polytechnic is a coeducational, independent university, accredited by the Middle States Association. The undergraduate chemistry program is approved by the American Chemical Society and undergraduate programs in aerospace, chemical, civil, electrical, industrial, mechanical, and metallurgical engineering are accredited by the Accreditation Board for Engineering and Technology.

The student body includes over 2,200 undergraduate students and 2,200 graduate students. Enrollment is one of the largest in the nation, and Polytechnic grants more engineering graduate degrees than all but a handful of other universities. Most students live in the New York metropolitan region, but students also come from throughout the country and the world to attend school here. About 13% of Polytechnic's students are women.

Polytechnic's presence is felt throughout the region. Its largest campus is located in New York City, in the commercial and governmental center of Brooklyn, across the Brooklyn Bridge from Manhattan's financial district, Wall Street. This campus offers all courses of study at all degree levels, and is the site of major research facilities and projects. A second campus, located in Farmingdale, Long Island, offers most undergraduate programs, and graduate programs particularly relevant to the aeronautical, computer, and engineering industries clustered in Long Island. The University's Weber Research Institute, and many of the aeronautical research activities, are located here. A Graduate Center in White Plains, Westchester County, provides graduate programs to people living and working in that high technology area. In addition, Polytechnic works with major corporations to provide graduate programs for employees at their places of work.

History

Polytechnic University's distinguished tradition dates to 1854. In that year Brooklyn Collegiate and Polytechnic Institute received its charter from the New York State Board of Regents, and New York University established its School of Civil Engineering and Architecture. Both schools began instruction in 1855.

In 1869 the Board of Regents authorized Polytechnic's collegiate department to confer Bachelor of Science and Bachelor of Arts degrees; the first 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 1920s; 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.

In 1961 the Long Island Campus was opened in Farmingdale as a graduate and research center.

In 1973, Polytechnic Institute of Brooklyn merged with New York University's School of Engineering and Science to become Polytechnic Institute of New York.

Since 1973, Polytechnic has continued to develop under the leadership of its president, Dr. George Bugliarello. A graduate of the University of Padua who holds a doctorate from the Massachusetts Institute of Technology, Dr. Bugliarello has brought not only his broad engineering and research background in such areas as biomedical engineering, computer languages, and fluid mechanics, but also his vision and concern for the broader role of technology in society and for Polytechnic's role as a great technological institution in the greater metropolitan area, serving the needs of the region and of the world, for which New York is the crossroads.

Under Dr. Bugliarello's leadership, the Long Island campus opened its undergraduate division in 1974 and the Westchester Graduate Center opened in 1976. New relationships, encompassing research and education, have been developed with major technological corporations throughout the region.

New research centers have been established in transportation, imaging sciences, fire safety, advanced telecommunications, and philosophy of technology.

Curricula have been revised to integrate computer applications in all fields. New courses in computer-aided design and computer-aided manufacturing have been developed, and a contemporary liberal arts core curriculum has been created for students majoring in humanities, communications, and social sciences. New degree programs have been instituted in specialized journalism, imaging sciences, telecommunications management and other areas.

In 1985, by action of the New York State Board of Regents, the Institute was renamed Polytechnic University, a new name which more accurately describes the range and quality of undergraduate and graduate programs as well as faculty research in engineering, the arts and sciences, and management.

Education Programs

Flexibility, innovation, and breadth of opportunity are the hallmarks of the Polytechnic educational experience. Educational programs can be taken on a full-time or part-time basis, in day or evening courses, and in summer sessions as well as fall and spring semesters, providing unusually great latitude for students to structure their studies to suit their needs. New programs of study are developed and traditional ones are revamped to keep pace with technological change and to broaden areas of inquiry related to science and technology.
Undergraduate

At the undergraduate level, all students receive thorough training in chemistry, physics, and mathematics, as the basis for more advanced specialized work. All students also take one sixth of their total course work in the social sciences, economics, history, and humanities, choosing from a wide variety of elective offerings. Undergraduates can take degrees in 15 different fields of science and engineering. All students have extensive opportunities to work closely with senior research and teaching faculty during their undergraduate years.

Of particular note are undergraduate degree programs in humanities, journalism and technical writing, and the social sciences. These programs provide students with the unique opportunity to combine a major in the liberal arts tradition and course work in a vast range of science and technology-related courses—a superb background for nontechnical careers in an increasingly technological society.

Graduate

Programs at the graduate level are designed to meet a variety of student needs. Programs leading to a Master of Science degree are available in 35 fields; engineering degrees are available in 10 fields; Ph.D. degrees are available in 20 fields. The graduate programs have two foci—one oriented toward professional career development, the other toward research. Specialized graduate certificate programs are also available for professional advancement.

Many of the MS programs are quite specialized within the general framework of technology. In addition to the major engineering and science disciplines, MS degrees are offered in transportation management, specialized journalism, polymer science and engineering, telecommunications management, industrial chemistry, history of science, environmental health science, and imaging sciences. Some of these programs have been recently developed to meet emerging needs: telecommunications management and imaging sciences are examples of pioneering education at Polytechnic. Some programs are particularly suited to our location: Polytechnic offers the most significant transportation management and transportation planning and engineering programs in the transportation capital of the world. Other masters programs, such as management or organizational behavior, take traditional areas of study and look at them from a technological perspective—management of manufacturing, telecommunications, or information. These programs are particularly suited to students with an undergraduate engineering background who are preparing to assume management positions in high tech companies.

Research Programs

Although students at all levels benefit from the advanced research taking place at Polytechnic, the Ph.D. programs are most closely intertwined with research efforts. The Polytechnic electrical engineering graduate program is ranked among the top in the country, and its faculty undertakes $2 million in sponsored research annually. The chemistry department has national prominence in the field of polymers and polymer synthesis, with a research volume of nearly $1 million a year.

Specialized research centers and clusters which draw on expertise in many disciplines address many of the fundamental technological challenges of today, provide a research focus for Ph.D. candidates in many fields. The oldest such centers are the Weber Research Institute (formerly the Microwave Research Institute) and the Polymer Research Institute. Others have been created more recently: The Digital Systems Center, with a focus on complex computer control systems; The Institute of Imaging Sciences, which spans chemical and computer aspects of imaging problems; and the New York State Center for Advanced Technology in Telecommunications, with a broad range of topics from telecommunications networks to office automation to software engineering.

Yet another new center, the Philosophy and Technology Study Center, is pioneering the development of a new area of scholarly pursuit, which affirms the University's broad perspective in its role as a technological institution.

Faculty

The Polytechnic faculty, numbering over 200, is committed equally to teaching and research. The faculty originates, organizes and approves all curricula taught at the University and also establishes academic standards for student achievement. There are few large lecture courses at Polytechnic. Most advanced undergraduate courses are taught by tenured professors. Faculty members act as student advisers and meet with students in lectures, seminars, laboratories and on field trips.

Faculty work with advanced graduate students to develop teaching and research skills as teaching assistants and research fellows.

Many faculty members have written undergraduate and graduate textbooks used throughout the United States. Several have received wide recognition for professional and research activities. In 1984, Professor Athanasios Papoulis, Professor of Electrical Engineering, was awarded the IEEE Education Medal in national recognition for his contributions to education and teaching.

Other awards to faculty members in recent years have included the National Medal of Science to Herman F. Mark, who is considered the father of modern plastics; the IEEE Microwave Career Award to Professor Nathan Marcuvitz; and the Halliburton Excellence in Research Award to Professor Erich Kunhardt. Polytechnic's faculty members have been among the founders of the National Academy of Engineering, The Institute of Electrical and Electronics Engineers, The American Institute of Chemical Engineers, and The American Society of Engineering Education.

Alumni

The Polytechnic Alumni Association promotes the welfare of Polytechnic and the individual alumni and alumna. As the need 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 helps sponsor various social activities for students including the annual Freshman Orientation. In addition, career symposiums featuring
prominent alumni speakers are held for all interested students. These symposiums illustrate the breadth of career opportunities open to Polytechnic graduates.

The Alumni Association has established a Student Alumni Association within its structure. 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.
CAMPUSSES AND FACILITIES

THE CAMPUSES

Brooklyn Campus
Polytechnic's Brooklyn campus is located at 333 Jay Street in downtown Brooklyn. This area is at a junction of public transportation lines and is accessible from all parts 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, the main library as well as the offices of the academic Deans and the Dean of Students.

The Administration Building, contains administrative and faculty offices, the Admissions, Bursar's and Registrar's Offices and the Office of Research and Graduate Studies.

William H. Nichols Hall, Johnson and Bridge Streets, houses the Placement Office, research facilities, laboratories, offices and classrooms.

The Student Center, located at 311 Bridge Street, houses a cafeteria, lounges, a video game room, a 6-foot T.V. screen, and student offices, and is the focal point for student co-curricular activities. The building is Open Monday through Friday; facilities are 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 9:00 AM to 7:00 PM Monday through Thursday, from 9:00 AM to 6:00 PM on Friday. Cafeteria hours are from 9:00 AM to 4:30 PM, Monday through Thursday and 9:00 AM to 2:00 PM on Friday.

Long Island Campus
The Long Island campus, on Route 110 in Farmingdale, was opened in the fall of 1961 for graduate study and research to fulfill the educational needs of Nassau and Suffolk Counties. In 1974 the Long Island campus was opened to undergraduates. There is a current enrollment of approximately 700 undergraduates with a wide range of student clubs and activities; there are also approximately 700 part-time graduate students. 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 research laboratories. 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 science-engineering library has 35,000 volumes of periodicals and reference works specifically selected to support the courses and research conducted at the campus.

The Preston R. Bassett Research Laboratory contains offices and laboratories of the Weber Research Institute for research in plasma physics, electromagnetic propagation and antennas, pulse power, acoustics, gaseous electronics, solid state and materials, quantum electronics, electric power engineering, automatic control and networks, and ultrahigh power microwaves as well as teaching laboratories.

Grumman Hall, the student center, houses a lounge, a game room, a bookstore, the student organization offices the Career Services Office, the Residence Life Office, and the Office of the Associate Dean of Students. During the regular academic year, it is open from 8:00 am to 8:00 pm Monday through Thursday and 8:00 am to 5:00 pm on Friday. The cafeteria — in the main building — is open the same hours.

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

The Athletic Facility is the newest addition to the Long Island campus.
Westchester Graduate Center
Scientists, engineers and managers employed at high technology companies in the Lower Hudson Valley and Southern Connecticut turn to the Westchester Graduate Center to fulfill their educational needs through participation in part-time Master's degree programs and courses of continuing education.

Classes at the Center in White Plains are held during late afternoons, evenings and on Saturdays, times most convenient for working professionals.

Educational offerings include courses in Computer Science, Electrical Engineering, Materials Science, Metallurgical Engineering, Chemistry, Management, and Telecommunications Management.

The Westchester Graduate Center is located at 456 North Street in White Plains. It is near major highways and particularly convenient for students not only from Westchester County but also from Southern Connecticut, Rockland county, and Northeastern New Jersey.

The Academic Building contains classrooms, administrative offices, the Richard Laster Library, a computer terminal room and a personal computer laboratory.

### FACILITIES

### LIBRARIES

The goal of the Libraries is to satisfy the recorded information and document needs of the students, faculty, researchers, and administration supporting the undergraduate, graduate, and research programs.

### SERVICES

Highly skilled librarians and information specialists offer the following:

1. Circulation of a book collection of over 100,000 volumes and a large Course Reserve Collection.

2. Reference assistance to locate the book, article, or information in Polytechnic which meets users needs.

3. InfoDash locates and retrieves journal articles requested from the Polytechnic Library or any of the major New York metropolitan area libraries.

4. Interlibrary Loan locates and retrieves books through a powerful international computer system (OCLC, with about 3000 libraries), and with other cooperatives such as the Academic Libraries of Brooklyn, the New York Metropolitan Reference and Research Library Agency, and the Long Island Library Resources Council.

5. Database Searching assists users, at cost, to do a detailed author, title, or subject search in virtually any area of interest from over 250 computer databases; prepares a printout of the journal, serial, and conference proceeding citations; and, in some instances, even provides abstracts of relevant papers and articles.

6. Other services include library orientation; requested classroom instruction; the maintenance of about 1200 journal subscriptions; an excellent collection of encyclopedias, almanacs, indexes and abstracts, biographical dictionaries, and other reference material.

The Brooklyn Library — This library has three public service sections: the Circulation Department, located on the first floor of Rogers Hall; the Reference Department, and the InfoDash Department, both located on the second floor of the Administration building (accessible from the stairs on the first floor of Rogers Hall). This library is the center of Polytechnic's library system, containing one of the best collections of technical and scientific literature in the metropolitan area, as well as materials in the humanities, social sciences and management.

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<tr>
<th>Location</th>
<th>Monday to Thursday</th>
<th>Friday</th>
<th>Saturday</th>
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<tbody>
<tr>
<td>Brooklyn Campus</td>
<td>9:00 AM to 8:30 PM</td>
<td>9:00 AM to 5:00 PM</td>
<td>1:00 PM to 5:00 PM</td>
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<tr>
<td>Long Island Campus</td>
<td>9:00 AM to 8:30 PM</td>
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<tr>
<td>Westchester Center</td>
<td>9:00 AM to 8:30 PM</td>
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Other Campuses and Programs

Westchester Graduate Center — Faculty and students can get toll-free library service by using the available hot line telephone in the Richard Laster Library Lounge or by calling the Brooklyn Library and having materials mailed upon request. Faculty and students at other approved extension programs are entitled to the same services and can obtain it by calling the Brooklyn Library.

NEW LIBRARY PLANS — Polytechnic University plans to break ground during the next fiscal year for a new 12 million dollar library and information center which will access information electronically from resources throughout the nation and the world. This new prototype facility will enable users in homes, offices, classrooms, and laboratories as well as the libraries to locate remotely and to retrieve information, books, journal articles, or documents when ever they are needed.
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 University's main computer facility, which houses an IBM 4341 and a DEC PDP 11/70 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 design and manufacturing. 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-mode computer network. In addition, the Long Island Center has access to all the computer facilities, including the computer-aided design and manufacturing system housed at the Brooklyn campus, and is equipped with a Personal computer laboratory.

RESEARCH CENTERS

CENTER FOR ADVANCED TECHNOLOGY IN TELECOMMUNICATIONS

The State of New York has designated Polytechnic as the host of the New York Center for Advanced Technology in Telecommunications (CATT). This designation recognizes Polytechnic's strong academic position in electrical engineering and computer science by providing funds for research and education in telecommunications.

Six research areas are active in the Center.

- Networks and Systems
- Devices and Propagation
- Office Automation
- Image Communications
- Government Systems
- Network Design

The Center also develops innovative educational programs to help users and providers of telecommunications services manage technological change and regulatory upheavals.

To this end, the Center has developed a curriculum combining special courses in telecommunications practices with electrical engineering, computer science, and management offerings. (Details of the Graduate program in Telecommunications Management are listed under the Division of Management).

The laboratories and educational programs within the Center provide greater opportunity for students to learn about the academic disciplines related to telecommunications and computer science.

Technological innovation is the sustaining force behind development of new industries, new jobs, and productivity improvements. To encourage the growth of technology based industries, New York State is implementing a comprehensive strategy which relies on an active partnership among business, labor, government, and its educational institutions. A key component of this strategy is a closer collaboration between the State's industrial community and its major universities to promote technology transfer.

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 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 VHSC 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. 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 presented in visual form. The Institute of Imaging Sciences (IIS), founded with a private gift of one million dollars, involves 15 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.

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 macromolecules and supervising research in that field. In addition, the "Polymer Science and Engineering" program 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 count among our graduates a large proportion of both academic and industrial scientists active in that field.

Otto Vogl was appointed in January, 1963 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.

WEBER RESEARCH INSTITUTE

In 1985 the world renowned Microwave Research Institute (MRI) was renamed the Weber Research Institute in honor of Dr. Ernst Weber who in 1943 founded MRI and served as the first director.

In the early days of MRI, the research programs consisted primarily of projects involving electromagnetics and microwave engineering. At present, the research programs at the Weber Research Institute encompass a wide range of topics within the broad field of electronics, such as Electromagnetic Propagation and Antennas, Pulse Power, Acoustics, Gaseous Electronics, Plasma Physics, Solid State and Materials, Quantum Electronics, Electric Power Engineering, and Automatic Control and Networks.

While the majority of faculty and students associated with the Weber Research Institute are in the Department of Electrical Engineering and Computer Science, there is also participation from the Physics, Chemistry, and Mechanical/Aerospace Engineering Departments. The activities of the Research Institute have fostered specialized graduate degree programs in electrophysics and microwave engineering.

Weber Research Institute projects are supported by a variety of industrial organizations and government agencies. The Institute was among the five original academic research centers to begin receiving funding from the Joint Services Electronics Program (JSEP) in 1955. That support has continued to the present day where we are now among the select group of fourteen institutions funded by JSEP.

The enviable reputation of the Weber Research Institute rests on the research publications and textbooks produced by the faculty; the impressions carried away by the numerous visitors who have spent time working in its labs or attending its symposia and workshops; and the achievements of the students it has trained.

PHILOSOPHY & TECHNOLOGY STUDIES CENTER

The Philosophy & Technology Studies Center is a unique venture integrating the humanities, sciences, social sciences, engineering, and management. It promotes interdisciplinary research into the inner structure of technology; its relationships to science and art; ethical responsibilities and political problems arising from technological design, production, and evolution; aesthetic analyses of engineering and the workplace; and the cultural impact of technological development and transfer.

To serve its purpose, the Center is developing a special research collection and hosts an annual New York Colloquium on Philosophy and Technology. It also sponsors course development, visiting scholars, special projects and publications. Center Associates form an international, consultative, scholarly network.

METROTECH

Polytechnic is the sponsor/developer of a $500,000,000 high technology center known as Metrotech. Working with New York City Public Development Corporation and a commercial co-developer, 16 acres surrounding Polytechnic's Brooklyn campus will be developed into a high-technology complex dedicated to creating closer industry-academic cooperation in research and development.

Metrotech will include a Technology and Science Library linked electronically to worldwide data sources. This library will 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 in Metrotech and the region, students will be able to keep pace with the most advanced information utilized by industries which provide employment opportunities for graduates of Polytechnic.

Over three million square feet of office, research and computer space will be made available to the private sector within the Metrotech complex. Corporations will have this space designed to meet their needs, with "intelligent" buildings developed to build in state-of-the-art telecommunications, security, operations, and energy management systems.

Metrotech will also contain the Center for Advanced Technology in Telecommunications, a prestigious designation by the State of New York achieved by Polytechnic in 1983. Industrial and educational objectives will be met through a close working relationship between Polytechnic and corporate technical and management personnel within Metrotech and throughout the region. Students will have the opportunity to observe at close range the application of lessons learned in the classroom as they are applied within high-technology corporations.

Adjacent to Metrotech will be a hotel/conference center, which will make it possible to bring scientists, engineers and managers to conferences of mutual interest to 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.

TRANSPORTATION TRAINING AND RESEARCH CENTER

The Polytechnic established the Transportation Training and Research Center (TTTRC) in 1975 to focus its research and non-degree training related to transportation. The Center has encouraged such research and has involved faculty from a number of the Polytechnic's departments and programs in research proposals and projects. In recent years, prospective principal investigators have come from transportation, industrial engineering, mechanical and aerospace engineering, electrical engineering, civil engineering, metallurgy, and social sciences.
Students are encouraged to become involved in the Center's research as research fellows, research associates, and project aides. In some cases, the student's education is fully funded by research. Recent projects within the Center have included the development of the 1985 edition of the Highway Capacity Manual and the related personal computer software development; demand estimation for a high-speed ferry system; trip generation estimation; fire-pavement noise investigations; evaluation of single cable communications in rail rapid transit; and policy studies on van-pooling, express buses, and local bus-routing. Training development work has covered highway capacity, transit management for middle managers, transit management for first line supervisors, and microcomputer applications.

The Center anticipates a continuing emphasis on its strengths in traffic and highway engineering, transportation planning, and transportation management, as well as stronger emphasis in infrastructure, computer aided engineering, telecommunications related to transportation, and freight and goods movement.

**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 bachelor's degrees either in four years of full-time study in the day session or over a longer period of time. The number of credits full-time students may take each semester depends upon the curriculum and ranges from 12 to 20.

Students are admitted as freshmen in September and January or February. Full-time students entering in September follow normal curricula outlined for fall and spring semesters. Those entering in January or February follow programs 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 selected branch of engineering, the sciences, management, the humanities or the social sciences.

GRADUATE PROGRAMS

Graduate study at Polytechnic is open on a full-time and a part-time basis to persons who hold bachelor's degrees from accredited institutions. Students may work toward graduate degrees — Master of Science, or 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 curricula guide and program descriptions under the various departments and to the Schedule of Classes available at the Office of the Registrar.

SUMMER COURSES

Polytechnic offers a wide variety of full-credit summer courses for full and part-time, undergraduate and graduate students during the summer months. The schedule of summer courses may be obtained from the Office of the Registrar.

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. The military science department also offers during the summer 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

<table>
<thead>
<tr>
<th>Name of Program</th>
<th>Hegis Code</th>
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<tr>
<td>Management and Business Administration</td>
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<tr>
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<td>Computer Applications</td>
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<td>Computer Mathematics</td>
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<td>Construction Management</td>
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<td>Econometrics and Forecasting</td>
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<td>Finance</td>
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<td>Production and Inventory Control</td>
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<td>Public Policy</td>
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<td>Public Transportation</td>
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<td>Transportation Facility Design: Operation</td>
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<td>Transportation Management and Economics</td>
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<tr>
<td>Transportation Planning</td>
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</table>
REGISTERED DEGREES OFFERED AT POLYTECHNIC

Polytechnic's programs lead to the Bachelor of Science, Master of Science, Engineer, and Doctor of Philosophy degrees. For more information on degree titles, descriptions and requirements, please see departmental sections.

<table>
<thead>
<tr>
<th>Degree Area</th>
<th>B.S.</th>
<th>M.S.</th>
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<tr>
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<td>Dental Materials Science (1224) (Joint with New York University)</td>
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<td>Humanities (4902)</td>
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<td>Manufacturing Engineering of Electronic Materials (0913)</td>
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<td>Transportation Planning and Engineering (0908)</td>
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</table>

*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 University
333 Jay Street
Brooklyn, NY 11201
(718) 643-2150

FARMINGDALE
Admissions Office
Polytechnic University
Route 110
Farmingdale, NY 11735
(516) 454-5150

Undergraduate applicants should complete the 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 that their secondary school or college 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 submit test scores of the Scholastic Aptitude Test (SAT) and Achievement Tests (ACT), or of the American College Testing Program (ACT).

Personal essays and teacher recommendations are welcome, but not required.

Polytechnic's admission process operates on a rolling basis; however, applicants are encouraged to apply early. Preference 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. Freshmen candidates for the fall term who apply after February 1 will receive an admission decision within two weeks after submission 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 December 1 for the spring semester, nor after June 1 for the fall semester. All official records, together with notarized translations, must also be received by these dates. (See International Applicants, page 16.)

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 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 Board examinations.

Secondary School Record

In as much as the course of studies at Polytechnic is academically rigorous and intellectually challenging, admission to Polytechnic is highly competitive. Candidates for admission will be judged primarily on their potential for success.

The preferred course of studies on the secondary school level is:

English—4 years
Foreign Language—2 years
Science—3 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)
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 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 the International Baccalaureate Exam, vary from department to department.

COLLEGE PREVIEW

Through Polytechnic's College Preview Program, students may gain college credit during their senior year of high school. Courses are offered to College Preview students at reduced tuition.

ADMISSION AS A TRANSFER STUDENT

Polytechnic welcomes transfer students from accredited colleges and universities, provided they have maintained a strong academic record. Students who have not completed two years of college work should submit official transcripts of previous college and high school grades, and Scholastic Aptitude Test scores. Students who have completed two or more years of college need only submit official college transcripts.

If accepted, transfer students should meet with a member of the admissions staff and a departmental adviser to determine which credits are transferable. Students are required to submit their college catalog describing courses under consideration.

Transfer credit is awarded on the basis of current standards and curriculum. Therefore, it is possible that credits which Polytechnic had previously awarded for courses taken at other universities may no longer be granted at this time. All transfer credit evaluations are conditional. Transfer credit will not be considered for any course with less than a "C" grade. Substandard performance in a course at Polytechnic will result in a reevaluation of transfer credit.

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 given by various departments. When course requirements are waived, the student will not receive credit for the course, but must substitute a more advanced course to satisfy the degree requirement.

The grades for transfer courses are not included in the computation of the Polytechnic grade point average. New transfer students may be admitted on a part-time or full-time basis and may be required to take some entrance examinations.

The minimum residence requirement for transfer students who wish to qualify for a bachelor's degree is thirty-four semester hours in approved upper class subjects taken at Polytechnic.

ADMISSION AS AN INTERNATIONAL STUDENT

Proficiency in English is a prerequisite for admission. 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 or J-1 visas must enroll as full-time students.

International students transferring from other United States institutions are required to submit the I-20 or IAP-66 obtained from Polytechnic to their present institutions in order to begin U.S. Immigration Service Transfer Procedures.

If transfer credit is desired, candidates 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 Admissions 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 consider family size, family members who are students and 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. HEOP is available at the Brooklyn campus only. For further information, contact the director of HEOP at the Brooklyn campus at (718) 643-5995.

ADMISSION AS A PART-TIME STUDENT

Students seeking a bachelor's degree 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 degrees in civil, electrical, and mechanical engineering can be completed during the evening session at the Brooklyn campus. In other disciplines, students will be required to take some courses during the day session in order to complete their degrees.

Regulations concerning subject requirements and admissions procedures are given in the section "Admission as a Freshman." However, part-time undergraduate applicants are not normally required to take the entrance examinations.
Following notification of acceptance, students should contact the adviser of the major department. In some cases, this may be accomplished during registration.

Undergraduate students may also register for a maximum of two courses per semester on a non-degree basis. Application 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.

**EARLY ADMISSION**

On occasion, Polytechnic offers early admission to outstanding high school juniors. Programs can be arranged so that students simultaneously satisfy high school requirements while completing their freshmen year of college. Candidates for this program must complete their entrance examinations in their junior year of high school and must present, with their application, a letter from their 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. If arrangements are made in advance, prospective students are welcome to have an interview with a member of the admissions staff during their visit to Polytechnic. This interview is not required as a condition for admission, but is a useful process for 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 (ABET), the American Chemical Society and the various regional accrediting associations. An applicant applying to a graduate program in an area of study different from the undergraduate field in which a bachelor’s degree or its international equivalent was earned must anticipate the possibility of additional courses for which graduate credit may not be given.

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 Office of Research and Graduate Studies, 333 Jay Street, Brooklyn, New York 11201, (212) 643-3693.

**ADMISSIONS PROCEDURES**

In addition to the application form and fee, an applicant must have transcripts of any previous undergraduate (and graduate) records sent directly to the Office of Research and Graduate Studies. An application should be supported by letters of recommendation from persons qualified to comment on the applicant’s aptitude for graduate study and research. Action on an application will be taken as soon as possible after all supporting documents have been received.

**EXAMINATIONS**

The Graduate Record Examination (GRE) or Graduate Management Admission Test (GMAT) is required for admission to some graduate programs. Consult the departmental section of this catalog for specific requirements about the degree program to which you are applying.

Information about GRE and GMAT may be obtained from the Educational Testing Service, 20 Nassau Street, Princeton, New Jersey 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 requested. An incomplete file will delay review and perhaps entrance by at least one term.

The Test of English as a Foreign Language (TOEFL) administered by the Educational Testing Service, is required from all foreign applicants who have earned a bachelor’s degree from an institution in a non-English-speaking country.

Certification of ability to meet financial obligations is also required.

**STATUS**

Within the full-time and part-time classifications of graduate students are four status groups: regular, conditional, provisional, and special. A change in status from conditional to regular should be applied for when the conditions of admission are satisfied. A special or provisional student must file an application for graduate admission with the Office of Research and Graduate Studies.

**Regular Status**

A graduate degree applicant who is adequately prepared to begin the program applied for is assigned regular status upon the recommendation of the major department.
Conditional Status

A graduate degree applicant who is required to demonstrate additional ability to pursue the program applied for is assigned conditional status. Conditions may include introductory level or undergraduate courses, or attainment of a specified grade point average.

Provisional Status

A graduate degree applicant whose admissions file is lacking documents necessary for academic evaluation may be permitted to register for one semester with provisional status upon recommendation by a faculty member and approval of the graduate Dean. The applicant must provide all required admission documents to the Office of Research and Graduate Studies before the sixth week of the semester. If the applicant is not accepted for admission, the semester can be withdrawn with full refund may be requested. Subsequent registration will not be permitted.

Special Status

An individual requesting permission to register for one or two courses in a specific semester is assigned special status. A formal application for admission may or may not have been filed with the Office of Research and Graduate Studies. Included in this status are individuals who want to take courses for professional advancement or personal development but who do not want to earn a degree, and part-time degree applicants with incomplete admission files. A maximum of six units or two courses may be taken in one semester and no more than nine units or three courses transferred to a Polytechnic degree program. A special student application must be filed each semester the individual remains in this status. Permission to take courses as a special student does not imply admission to a degree program.

Graduate Probation. A graduate student is expected to progress in the studies pursued and to maintain a B (3.0) average. Failure to do so can result in "academic probation." To compute a graduate grade-point average, the following schedule is used:

<table>
<thead>
<tr>
<th>Letter Grade</th>
<th>Grade-Points</th>
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<tbody>
<tr>
<td>A</td>
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<tr>
<td>B</td>
<td>3.0</td>
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<td>C</td>
<td>2.0</td>
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<tr>
<td>F</td>
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Repeated courses will count only once in the grade-point average, with the higher grade being used.

After the posting of spring grades, any graduate student whose grade-point average is below 3.0 will be notified that they are on academic probation. The data for such determination will be provided by the Registrar’s Office, and copies of all probation notices will go to each department, which will check the accuracy of the grade-point determination.

An academic department may 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 sent to the Office of Research and Graduate Studies.

A graduate student on academic probation may not register for further courses without the written permission of the department head and concurrence of the Office of Research and Graduate Studies. When 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 to retain permission to register in future semesters. This statement will be kept on file in both the Office of Research and Graduate Studies and the departmental office. A student may be denied permission to register by the academic department or the Office of Research and Graduate Studies any time while on academic probation. Students are cautioned that failure to maintain a 3.0 grade-point average may result in loss of regular 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.

EARLY GRADUATE ADMISSION

A Polytechnic undergraduate student within 18 credits of completing the B.S. degree and otherwise meeting all criteria for graduate admission may apply for admission to graduate study in a given department. If accepted, the student will be pursuing two degrees simultaneously, 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 a master’s degree program.
FINANCIAL AID

UNDERGRADUATE

Polytechnic University 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 University, and independent and government funds).

All financial aid is limited to the needs of the students as determined by the College Scholarship Service. Students receiving financial assistance from Polytechnic University 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 academic ability and financial need which do not require repayment.

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

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

About 85 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. Incoming freshmen 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 May 1, and request a financial aid transcript from the transferring institution to be sent to the Financial Aid Office at Polytechnic University by May 15.

To Renew

1. Students should request the Financial Aid Form from the Director of Financial Aid in February - March.

2. Students should file the FAF with the College Scholarship Service, Princeton, New Jersey, by March 15.

3. Students should file the Polytechnic Financial Aid Application with the Office of Financial Aid by March 15. A copy of the parents' 1040 or 1040A and/or the student's 1040 or 1040A tax forms 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. Applicants must show need and be enrolled at least half-time as an undergraduate student.

Award schedule. Awards range 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.

Responsibilities. Students 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 a NDSL for the first two years of study.

Responsibilities. The current interest rate, payable during the repayment period, is 5 percent 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 the Peace Corps, VISTA, or similar national programs.

College Work-Study Program (CWSP)

Application procedures. Awards are determined by the Financial Aid Office. Students must have filed a Financial Aid Form (FAF). After eligibility is determined, work arrangements are made through the Personnel Office.

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

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. Applications should be completed according to directions or students should apply for the Pell Grant by checking the appropriate box on the FAF. Student Aid reports will be sent to applicants from the Department of Education. Based on an eligibility index, the amounts of Pell Grants are determined by the Financial Aid Office. Upon enrollment, funds are paid directly to Polytechnic in the student's name.

Selection and allocation. The Pell Grant program is an entitlement program. Scholaristic accomplishment has no bearing on eligibility. Applicants must be enrolled as undergraduates at least half-time. Financial need 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 $250 to $2,100, but not more than one-half the total cost of attendance. Awards are determined by costs of attendance and full- or part-time enrollment status. Pell Grants do not duplicate state awards.

Rights and responsibilities. Students must make satisfactory academic progress, must repay Pell Grants and other awards, or be in default of any student loans. Before receiving payment, students must sign an affidavit that all money will be used only for the costs of education. Most Pell Grant payments are credited directly to the student's University accounts.

Veterans Administration (VA) Educational Benefits

Application procedures. Applications are available at all VA offices, active duty stations and American embassies as well as 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 earned each semester. Any questions concerning veterans benefits or paperwork should be directed to the Veteran Affairs clerk, either in person or by telephone.

Selection and allocation. Veterans who served over 180 days between January 31, 1955 and January 1, 1977 and (1) continue 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 and 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.

Responsibilities. Interrupted attendance or termination of study by students receiving VA benefits must be reported. Details of Polytechnic's requirements are given to all applicants. Eligible students must apply for certification each semester at the Office of Student Records.

ROTC Scholarships

Army ROTC offers four-, three-, and two-year scholarships. The four-year scholarships are awarded on a worldwide competitive basis to American citizens entering college as freshmen. The three- and two-year scholarships are awarded competitively to students enrolled in college and 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 and lab fees, plus a living allowance of up to $1,000 for each year the scholarship is in effect.

NEW YORK STATE-BASED PROGRAMS

Tuition Assistance Program (TAP)

Application procedures. Applicants must apply annually to the New York State Higher Education Services Corporation (HESC), 99 Washington Avenue, Albany, NY 12255. The application deadline for the 1986-87 academic year is March 31, 1987. The HESC determines the applicant's eligibility with an award certificate indicating the amount of the grant. Applicants present a copy of the certificate when tuition is paid. Polytechnic will defer payment upon receipt of the certificate.

Selection and allocation. TAP is an entitlement program. Applicants must (1) be New York State residents and U.S. citizens or permanent residents; (2) enroll full-time at an approved New York State post-secondary institution; (3) have, if dependent, a family net taxable income below $29,000 or if independent and single with no tax dependents, a net taxable income below $5,667; and (4) be charged tuition of at least $200 per year.

Undergraduate students 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 1986-87 academic year, full-time dependent students can receive awards ranging from $300 to $2,700.
Responsibilities. Students must meet satisfactory academic requirements after each increment of 12 semester hours is completed. Additionally, students must satisfy program requirements stipulating that students earn passing grades in the minimum course load in each term an award is received.

AID FOR PART-TIME STUDY (APTS)

Application procedures. Applications and other materials are available at the Financial Aid Office. Applications should be completed and returned to the Financial Aid Office as soon as possible. Students must apply annually. Applications should be filled no later than the second week of classes for the following semester.

Selection and allocation. To be considered for an award, students must: (1) be working toward an undergraduate degree as part-time students enrolled for at least 6 and not more than 11 credits per semester; (2) have completed a bachelor's degree or the equivalent; (3) have earned at least 6 credits per semester; (4) retain good academic standing; (5) be residents of New York State; (6) be either American citizens, permanent residents, or refugees; (7) not have used up TAP or other New York State financial aid eligibility for full-time study; (8) have tuition charges of at least $100 per year; (9) have, if dependent, a family net taxable income below $22,000, or if independent, and not eligible to be a tax dependent, a single student's (or, if married, combined) net taxable income cannot exceed $15,000.

Award schedule. The program provides up to $2,000, but may not exceed tuition charges.

VIETNAM VETERANS TUITION AWARDS SUPPLEMENT (VVTAS)

Application procedures. Applications and other materials are available at the Veterans Office, any Veterans Office, or by writing to the New York State Higher Education Services Corporation, VTTA, Albany, NY 12255. Applications for the Vietnam Veterans Tuition Award Supplement must be made by March 31, 1987 by part-time students. Full-time students must apply by submitting both Vietnam Veterans Tuition Award Supplement and the Student Payment Application (TAP Application) by March 31, 1987.

Selection and allocation. The Vietnam Veterans Tuition Award is an entitlement program. Applicants must: (1) be residents of New York State since April 20, 1984, or at the time entry into service and resumption of residency by September 1, 1987; (2) have served in the U.S. Armed Forces in Indochina between January 1, 1963 and May 1, 1975; (3) be honorable or medically discharged from the U.S. Armed Forces; (4) be enrolled in an approved undergraduate program in a degree-granting institution in New York State; and, (5) have applied for Tuition Assistance Program (TAP) and Pell Grant awards. There are no income restrictions connected with this program.

Award schedule. The award provides up to $500 per semester (full-time attendance) or $250 per semester (part-time attendance). If a Tuition Assistance Program award is received, the combined awards cannot be greater than tuition. The TAP award will be reduced accordingly.

Awards are available for up to 8 semesters (4 years), or 10 semesters (5 years) of undergraduate study if programs are specifically requiring 5 years for full-time study and double the amount of time for part-time study.

Responsibilities. Students must meet satisfactory academic requirements after each increment of 12 semester hours is completed. Additionally students must satisfy program requirements stipulating that students must earn passing grades in the minimum course load in each term an award is received.

Regents College Scholarship

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

Selection and allocation. Regents College Scholarships are awarded on a competitive basis. Applicants must (1) be legal residents of New York State for at least one year immediately preceding the first term for which application of an award is made; (2) have been in attendance at a high school no more than six years before 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 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. Students should obtain a loan application from participating state lending institutions (banks, credit unions, etc.) in the state or permanent residence along with the GSL Needs Test Form. Completed applications should be presented to the Polytechnic Financial Aid Office for certification. Applications are then forwarded to the lending institutions and the appropriate state agencies.

Selection and allocation. To be eligible for a guaranteed state loan, students must (1) be American citizens or permanent resident aliens; (2) be enrolled in or admitted at least half-time at an approved post-secondary institution; and (3) prove need in that taxable family income is over $30,000.

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

Responsibilities. Students may borrow at a relatively low interest rate (currently 8 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 or service in the Armed Forces, Peace Corps or Domestic Service.

If students apply for an additional loan, application must be made at 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.
Responsibilities. Satisfactory academic progress must be maintained.

Parents Loan For Undergraduate Students (PLUS)

Application procedures. Students should obtain loan applications from participating state lending institutions (banks, credit unions, etc.) in the state of permanent residence. Completed applications should be presented to the Polytechnic Financial Aid Office for certification. Applications are then forwarded to the lending institutions and the appropriate state agencies.

Loan schedule. Parents of undergraduates may borrow up to $3,000 per year not to exceed $15,000 for total undergraduate study.

Responsibilities. When dependent students need even further assistance, the PLUS loan is available to their parents. No criteria of need are connected to PLUS. The loan is unsubsidized (currently carrying a 12 percent interest rate); payments begin within two months of receiving the check. Parents, not students, are responsible for repayment.

Auxiliary Loans to Assist Students (ALAS)

Application procedures. Students should obtain loan applications from participating state institutions (banks, credit unions, etc.) in the state of permanent residence. Completed applications should be presented to the Polytechnic Financial Aid Office for certification. Applications are then forwarded to the lending institutions and the appropriate state agencies.

Selection and allocation. Eligibility criteria for the ALAS loan are the same as the Guaranteed Student Loan except the borrowers cannot receive more than $2,500 in any single academic year (including whatever may have been borrowed under the GSL program).

Loan schedule. Combined borrowings from the Guaranteed Student Loan and Auxiliary Loan to Assist Students cannot exceed $12,500 for undergraduate studies.

Responsibilities. Independent undergraduate students, who are not eligible for the ordinary GSL, may seek help from this program. The loan is unsubsidized (currently carrying a 12 percent interest rate); payment begins immediately upon completion of studies or after full-time enrollment.

INSTITUTIONAL LOANS (Limited resource - dependent on available funds)

Application procedures. Students can apply directly to the Financial Aid Office using the Financial Aid Forms (FAF). After eligibility is determined, students are notified via award notifications.

Selection and allocation. Applicants must be enrolled at least half-time (6 credit hours). Eligibility is primarily based on need; special circumstances can influence determination. Students must be U.S. citizens or permanent residents.

Responsibilities. Students are generally allowed to borrow up to $2,000 per academic year. Interest rates are variable. Repayment begins after graduation or after leaving school.

ALTERNATE FINANCING

While Polytechnic has no deferred payment plans, alternate financing options are available through banks and lending institutions. These programs generally provide installment payment opportunities.

SCHOLARSHIPS AND GRANTS

Polytechnic has a history of scholastic recognition to numerous applicants with outstanding academic credentials. Such awards are based on need, academic achievement, recommendation and outside awards.

• Polytechnic Scholarships are awarded to freshmen and transfer applicants with strong academic backgrounds with full-time schedules (12 credit hours). Awards are determined through demonstrated financial need and merit. Students apply directly to the Financial Aid Office using the FAF. Awards range up to $4,500. Continuance of the awards demands maintenance of a 2.5 cumulative grade point average and application to the Pell and TAP programs.

Board of Trustee Scholarships are awarded to academically superior freshmen. Applications are made directly to the Admissions Office. Amounts of the scholarships are equal to tuition, less any outside aids for which the students are eligible. Continuance of the scholarship is based on maintaining a 3.0 cumulative grade point average and application to the Pell and TAP programs.

• Contemporary Liberal Arts Scholarships are awarded to academically superior freshmen majoring in Humanities or Social Sciences. Applications are made directly to the Admissions Office. The amounts of the scholarships are equal to tuition, less any outside aids for which the students are eligible. Continuance of the award is based on maintaining a 3.0 cumulative grade point average and application to the Pell and TAP programs.

• Geiger/Fialkov Scholarships are awarded to superior freshmen and transfer students majoring in Engineering or Computer Science. Applications are made directly to the Admissions Office. The amounts of the scholarships are equal to tuition, less any outside aid for which the students are eligible. Continuance of the award is based on maintaining a 3.0 cumulative grade point average and application to the Pell and TAP programs.

• Division of Arts and Sciences Scholarships are awarded to superior freshmen and transfer students majoring in Chemistry, Humanities, Mathematics, Physics or Social Sciences. Application is made directly to the Admissions Office. The amounts of the scholarships are equal to half tuition. Maintenance of the awards is based upon recommendations by Department Head and application to the Pell and TAP programs.

• Metallurgy and Materials Science Scholarships are awarded to academically superior freshmen and transfer students majoring in Metallurgy. Applications are made directly to the Admissions Office. The scholarship award is up to $1,000. Maintenance is dependent upon high academic performance.
• Outstanding Achievement Scholarships are awarded to full-time, continuing students (sophomore, junior, and senior) with a cumulative grade point average of 3.5 or higher who are not receiving any other Polytechnic scholarships. Applications are made directly to the Financial Aid Office. Minimum awards are $500. Maintenance is dependent upon a 3.5 cumulative grade point average.

• Polytechnic Grants are available to needy students on a limited basis. Students should apply directly to the Financial Aid Office.

• National Action Council for Minorities in Engineering (NACME) Grants are awarded to minority (Black, Hispanic, American Indian) students with strong academic backgrounds who demonstrate financial need. Awards are determined by the Financial Aid Office after students being classes and range up to $2,500. Maintenance is based upon 2.5 cumulative grade point average.

• Polytechnic National Society of Professional Engineers Scholarships (NSPE) are awarded to academically superior freshmen majoring in Engineering. Awards are determined by NSPE and range up to $1,500. Maintenance is based upon high academic performance.

• Polytechnic Matching Mayor's Committee Scholarships are awarded to recipients of a Mayor's Scholarship. Scholarship amounts range between $100 - $650. The application deadline for Mayor's Scholarships is October 1. Applications are available at high schools or the Financial Aid Office.

**IMPORTANT FINANCIAL AID POLICIES**

• To be eligible to receive financial aid, students must be enrolled at least half-time. All Polytechnic Scholarships, TAP grants, and Regents Scholarships, however, require students 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 have no access to financial aid records. Academic evaluations of a student's qualifications are made without knowledge of the applicant's financial need.

• Prospective students should 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 reviewed for financial aid.

• Financial aid is renewable annually, based on students reapplying, continuing to demonstrate financial need where applicable, and fulfilling other requirements stipulated by the awards. To renew most Polytechnic Scholarships, students must maintain a 2.5 cumulative grade point average. To renew a Board of Trustee Scholarship, students must maintain a 3.0 cumulative grade point average.

• Since Financial Aid and Scholarship Funds administered by Polytechnic 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 the fixed amount of resources, Polytechnic deems it unethical to withdraw support from students who have based attendance at Polytechnic on the financial aid awarded them in order to release funds to assist new applicants. Funds from financial aid programs not administered by Polytechnic, such as the Pell Grants, TAP, and the Guaranteed Student Loan Program, are available to eligible students whether or not students have already received funds from these programs.

• Grants of Title IV Aid (Pell, Supplemental Educational Opportunity Grant, College Work Study, National Direct Student Loan and the Guaranteed Student Loan) are contingent upon provision of the following documents: 1) properly signed Financial Aid Acceptance Forms explaining the terms of the awards; 2) Financial Aid Transcripts from all previously attended institutions of higher education; 3) copies of student's; (or parents') IRS Form 1040 or 1040 A/EZ, if requested; (4) signed affidavits acknowledging Selective Service Registration; and (5) proof of permanent residency status.

Students receiving financial aid from federal or state sources, must be studying toward a degree according to the standards set forth in the Academic Policies of this catalog.

Terms of eligibility for financial aid are calculated by the total time of students enrollment at Polytechnic. Students, therefore, can be making satisfactory progress toward their degree, but potentially exhaust their eligibility for financial aid from New York State by not completing their degree requirements within the stipulated eight semester terms of eligibility.

Students may request waivers of the standard of minimum satisfactory progress during one term. Such a request should be made to the Dean of Students.
UNDERGRADUATE GRANTS AND SCHOLARSHIPS

- The Sidney G. Albert Scholarship
- The Alumni Scholarship
- Louis Calder Foundation
- The J. B. Chittenden Scholarship
- The Arthur Clapp Scholarship
- Con Edison Scholarship
- The DaWitt Scholarship
- Dow Corning Corporation
- The Aaron and Simcha Dubitsky Scholarship
- The W. E. Duray Scholarship
- The A. S. Dwight Scholarship
- The Evnine Foundation
- The I. W. Fay Scholarship
- The J. Robert Fisher Scholarship
- General Foods, Incorporated
- Key & John Giba Scholarships (United Technologies)
- Gibbs & Hill, Incorporated
- The Richie Goldish Athletic Scholarship
- Hearst Foundation
- The Alfred Helwig Scholarship
- Hughes Communications Satellite Services, Incorporated
- Jepson Educational Trust #1
- The Jacob Kaplan Scholarship
- The Eugene R. Kulka Scholarship
- The John F. Kunc Scholarship
- Litton Industries
- The P. R. Mallory Memorial Scholarship
- Raymond Mauro Scholarships
- The NSC-Essie Mitchell Scholarship
- The Colonel Frank Mott Scholarships
- The William Nichols Scholarship
- The Nippon Electric Scholarships
- Sperry Rand Scholarship
- The Raytheon Company Scholarship
- The Julian Rogoff Scholarship
- Myron Rosenthal Scholarship
- Samuel Rubin Scholarships
- Schlumberger Foundation Collegiate Award
- The Frank R. & Emile E. Stamer Scholarships
- William States Scholarship Fund
- Michael Tuch Foundation, Incorporated
- Sterling Drug Chemical Scholarship Fund
- The Ernst & Sonya Weber Grants

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. An applicant must hold a degree from an institution of recognized standing. A new student can apply by completing the appropriate question on the "Application for Graduate Admission" form. A continuing student should consult the academic 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 study. 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 academic departmental office concerned.

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 doctoral research requirements of the graduate curricula in which they matriculate.

Reduced Tuition Program for High School and Two-Year Community College Teachers

A reduced tuition program is offered for full-time high school and two-year community 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 into a graduate program through the formal Polytechnic admissions procedure.

Written verification of employment as a full-time high school or college teacher, signed by the applicant's department head and an officer of the institution, must be submitted at each registration. Substitute, part-time, adjunct, or temporary appointments are not valid. Only those holding full-time, permanent teaching appointments in a public or private secondary school or an accredited two-year community college located in the New York metropolitan area are eligible to participate in this program.

This 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.

Loans

Funds donated by the United States Steel Foundation and the Ford Foundation, as well as funds donated in memory of Raymond Kirk, have made it possible for full- and part-time graduate students to obtain loans from Polytechnic.

In both programs the maximum amount of the loan is limited to one-half tuition per semester. An applicant must be registered in a degree program and be an American citizen. More information can be obtained from the Schedule of Classes or the Office of Research and Graduate Studies.

encouraged.
TUITION AND FEES

Information on tuition and fees can be obtained from the Schedule of Classes available before the start of each semester. The Registrar, Bursar and Admissions offices also have data available.

For fall 1986, full-time tuition for undergraduate students (12 to 20 credits) is $4,600 per semester. Students enrolled for fewer than 12 undergraduate credits pay $300.00 per credit. Full-time tuition for graduate students is $4,700 per semester, and for part-time graduate courses $330 per credit.

More than 20 credits must be paid for individually per credit.

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

Tuition covers instruction costs, use of the libraries and the facilities of the Student Center. Laboratory fees, ranging from $20 to $60 per semester, are charged for various laboratory classes. Details of these charges are given in the Schedule of Classes, since they vary from semester to semester. Courses requiring laboratory fees are indicated in the course listings.

Other costs, also detailed in the Schedule of Courses, include new student fee, facilities fee, student activity fee, 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 the Dean of Students.

The Bursar collects all payments at Polytechnic University. Full tuition and fee payments are due from all students at the time of registration. Payments must be made by cash, check, money order or credit card. Visa and MasterCard are accepted. Evidence of any financial aid should be presented at registration.

Deferred Payment

Polytechnic has no deferred tuition plan. However, outside agencies provide independent tuition deferment arrangements. Information about these agencies can be obtained at the Polytechnic Financial Aid Office. Special education loan programs for both graduate and undergraduate students enable families or students themselves to repay over extended periods in monthly installments and are available at many neighborhood banks. Families may qualify for a New York State Higher Education Assistance Loan. Applications are available at local banks. These loans normally take from six to eight weeks to arrange and process. Consult the Financial Aid section of this catalog for more information.

ESTIMATED COSTS—
ACADEMIC YEAR 1986-87
FOR UNDERGRADUATE STUDENTS

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ESTIMATED EDUCATIONAL COSTS—
ACADEMIC YEAR 1986-87
FOR INTERNATIONAL STUDENTS*

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<td>Insurance**</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Books and Supplies</td>
<td>475</td>
<td>475</td>
</tr>
<tr>
<td>Total:</td>
<td>$16,335</td>
<td>$16,535</td>
</tr>
</tbody>
</table>

REFUND OF TUITION

All students upon registration, assume obligation for the semester's tuition and other fees. In the event of withdrawal, the right to a refund must not be assumed. Whenever students withdraw from a course or from all courses, tuition charges are adjusted according to the schedule outlined below, provided that:

1) the withdrawal notice is filed within the refund period;

2) it is submitted in writing to the Registrar;

and (3) the withdrawal lowers the student's program to less than 12 credits.

Withdrawal forms are available in the Office of the Registrar. Filing a withdrawal form in that office is sufficient notification 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 the Registrar not the last date of class attendance.

Refunds must be requested from the Bursar's office in writing. If no requests are received, the refund amounts will be credited to the student's account. Students will be notified periodically of credit balances so that they may request refunds.

*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 students make official withdrawal from all courses at the University before the first day of classes, 100% is refunded; otherwise, the following refund applies:

<table>
<thead>
<tr>
<th>Withdrawal during</th>
<th>% Refund</th>
</tr>
</thead>
<tbody>
<tr>
<td>First week of semester</td>
<td>90%</td>
</tr>
<tr>
<td>Second week of semester</td>
<td>75%</td>
</tr>
<tr>
<td>Third week of semester</td>
<td>50%</td>
</tr>
<tr>
<td>Fourth week of semester</td>
<td>25%</td>
</tr>
<tr>
<td>After the fourth week of semester</td>
<td>0%</td>
</tr>
</tbody>
</table>

The processing of credits and refunds occurs two months after the start of each semester.

Appeals to the refund schedule must be submitted in writing, with documentation of reasons that exceptions should be made, to the Registrar.

**Financial Aid Refund Policy**

If the University determines that a student is due a refund, and if that student has received Title IV aid, a portion of that refund will be returned to the aid program according to the following formula:

\[
\text{Amount to be returned to Title IV programs} = \text{Refund} \times \frac{\text{Title IV aid for the payment period (minus work-study earnings)}}{\text{Total aid for payment period (minus work-study earnings)}}
\]

In refunding monies to the various financial aid programs, the following priority listings will be used:

1. Guaranteed Student Loan Program (G.S.L.)
2. PELL Grant
3. Supplemental Educational Opportunity Grant (SEOG)
4. National Direct Student Loan (NDSL)
REGISTRATION

Polytechnic University endorses close faculty-student relationships. The faculty advising system is the basis for selection of courses and registration. Each academic department identifies a group of faculty to serve as student advisers. Before registration, students should meet with their 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 Students.

Information about registration and registration appointments is mailed to continuing students prior to the registration period.

Procedure

All continuing full-time students (graduates and undergraduates) 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 reprocessing fees of $40. To receive 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 the Registrar.

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

Program Adjustments (Add/Drop)

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 program adjustment forms from the Office of the Registrar. To add or drop courses students must have written approval of the major adviser.

All students have responsibility of registering for conflict-free schedules. In instances of student-scheduled conflicts which necessitate course changes after registration, the add-drop fee will not be waived.

Fees will be charged for adding or dropping courses or changing sections, except where scheduled changes are necessitated by course cancellations, section adjustments, or 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 each 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. Fees may be waived by the Registrar in clearly justifiable cases.

Course Prerequisites

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

Student Identification

All students are required to carry and maintain at all times photo-identification cards issued by the Office of the Registrar. The photo-IDs must be presented at each registration for validation and shown to staff members of the Office of the Registrar when making changes in registration or requesting transcripts. IDs must be presented and/or surrendered to any officials of the University upon request.

Student ID numbers are used to identify individual records (billing payments, grades, etc.) for students' entire tenure at Polytechnic, from the time of admission to the completion of degrees. Student ID numbers are sometimes social security numbers, but not always. If students do not have social security numbers when admitted (as in the case of international students), students are assigned numbers by the Admissions Office. These assigned numbers will be permanent throughout students' careers at Polytechnic and will not be changed, even if social security numbers are obtained later.
DEGREE REQUIREMENTS

CREDITS AND UNITS

Undergraduate semester credits are based upon the number of 55-minute periods scheduled each week during 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. The final examination period is an integral part of the semester.

Graduate studies are expressed in terms of units. One 55-minute period of graduate class work for a semester carries 1 1/5 graduate units. A standard course meeting 2 1/2 academic periods a week would be equivalent to three units. Courses meeting more or less than 2 1/2 academic periods a week carry a proportionate evaluation.

CREDITS FOR COURSES TAKEN ELSEWHERE

Undergraduates

Students entering Polytechnic with advanced standing will receive appraisals of substitutions allowed based upon credit transferred from their former colleges. Senior subjects or their equivalent, determined in consultation with departmental advisers, are to be taken at Polytechnic. Minimum residence requirements for the bachelor's degree are one continuous year of full-time study or the equivalent part-time. See page 15 for further details concerning undergraduate transfer credit policies.

Graduates

A limited number of units for graduate courses completed with honor grades (A or B) by students from accredited institutions may be allowed toward meeting the requirements for master's or doctor's degrees provided these courses were acceptable at those institutions for similar degrees, usually after obtaining the bachelor's degree. Such transfer credits/units are 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 undergraduate degree requirements. Such courses are considered to be transfer units, subject to the nine unit limitation for the master's degree, since the student was not in residence as a graduate student when the courses were taken.

Transfer Credits While in Residence

Students in residence are expected to take the course work which is required at Polytechnic. Exceptions can be made in cases in which Polytechnic does not offer courses of importance to the attainment of the student's academic goals.

To obtain credits/units for courses taken elsewhere while in residence at Polytechnic, written permission must be obtained from the academic advisers and the department heads of the courses for which credits are requested, before the start of courses (forms for such permission are available in the Office of the Registrar.) The following requirements may apply:

- The other institutions must be accredited.
- Grades earned must be at least C for undergraduate programs and B for graduate courses.
- Pass/fail courses are not acceptable.
- Only credits/units will be granted. (Grades are not computed in the cumulative averages).

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 all fields of concentration, a program of study (curriculum) is prescribed. The student is admitted to register in one of these programs. Subsequent transfer to another program requires approval by the head of the new department. The change becomes official only after the proper form has been received by the Office of the Registrar. To qualify for the degree the student must complete the program as outlined in the respective departmental section of this catalog.

University Degree Requirements—In the humanities and social sciences, students must take HU 101 and either HU 200 and SS 104 or IS 140 and IS 141. Students 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).

All undergraduate students are 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—The University requires that all undergraduates take at least 24 credits in the humanities and social sciences. Nine of these credits must be taken in the courses listed above under University Degree Requirements. As part of the remaining 15 credits, students are strongly urged to select a specific area in which to concentrate their studies (such as literature, communications, the arts, philosophy, or comparative religions in the Department of Humanities and Communications, or economics, history, anthropology, or psychology in the Department of Social Sciences). In consultation with their adviser, students elect a number of courses within the chosen area. A modern language may be chosen as a suitable area; however, students without prior knowledge of the language must plan to devote at
least 12 credits to it. Additional courses in the humanities and social sciences may be taken as free electives.

Undergraduates enrolled in an engineering degree program must take a minimum of 18 credits in the humanities and social sciences as defined by the Accreditation Board for Engineering and Technology (ABET). These credits may not include skills-oriented courses such as technical writing, public speaking, or English as a second language. Courses in literature, foreign languages, history, economics, and others are acceptable. Students should consult their advisor to ensure that the above criteria are met. (These credits also fulfill part of the University requirements for these subject areas.)

Degree Requirements

Students are required to fulfill the following three conditions in order to be certified for bachelor’s degrees:

- Fulfill all University and departmental course requirements
- Earn the required number of credits for the Degree Program
- Maintain a 2.00 cumulative grade point average

Graduation Check List

Undergraduates who are nearing graduation receive a graduation check list which shows the completed courses and their assignment to required areas of study, and lists the courses which remain to be completed for the degree. After approval by the academic department, the graduation check lists are mailed to the students by the Registrar together with a copy of the transcript; this is usually done in March of the year preceding the prospective graduation.

Full-time students receive their graduation check list after completion of 85 credits. This check list remains valid for one and one half calendar years; a revised list may be issued for any student who does not complete the degree requirements within this time span.

Part-time students are issued a graduation check list after accumulating 105 credits. Students who complete their courses within eight calendar years from the time of their first entry may qualify for the degree under the curriculum in effect at that time, provided that the needed courses are still offered. The eight year period is proportionately reduced for transfer students and for students who were registered full-time during a portion of their attendance. After the expiration of the eight year period the department may issue a revised graduation check list.

Because of curriculum and course changes it is occasionally necessary to substitute courses to meet degree requirements. Such substitutions must be documented, either on the graduation check list or on the adjustment of degree requirement form obtainable from the Registrar. All substitutions must be approved by the student’s department and by the dean of the academic division.

Students who interrupt the continuity of their registration by a period of one year or more must meet the requirements in effect at the time of the resumption of studies, unless they have been granted a leave of absence which explicitly allows them to pursue the old curriculum after reentry.

Senior Honor Students

Each spring departments select 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 they are selected, and are given special permission to make substitutions in their selection of senior courses (e.g., substituting more advanced or graduate courses in place of the usual requirements).

To be eligible for this designation, transfer students must complete at Polytechnic at least one-half of the credits needed 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 are 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 credits required for the particular degree.

Dual Major

A student who meets the commencement requirements in two disciplines is to receive a bachelor’s degree indicative of that accomplishment, provided that the student:

1. is assigned a “home” department which will be responsible for the student’s primary first major,
2. applies for and is admitted to the second program in the same manner as a student who wishes to change departments, and
3. has, prior to graduation, approval from each department of the courses for its major.

Requirements for the Master’s Degree

All students 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, students must have a 3.0 grade-point average or better in all graduate courses and a 8 or better average in all guided studies (readings, project, thesis, and dissertation).

Students may offer no more than 12 units of project or thesis toward degree requirements. Registration for the project or thesis must be continuous until grades are recorded.

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

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

**REQUIREMENTS FOR THE ENGINEER DEGREE**

Candidates for the Engineer degree must complete a minimum of 36 units of work beyond the master's degree. This work will include a project or evidence of equivalent experience. A maximum of 12 units of project may be submitted toward fulfilling degree requirements. At least 27 units of work must be completed at Polytechnic. Registration for a project or thesis must be continuous until grades are recorded.

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 Office of Research and Graduate Studies.

The student must maintain a 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 an adviser 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 program chosen.

All candidates for doctorates must complete three years of full-time study or the 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 specific course requirements. A minimum of 30 units, including dissertation units, must be taken at Polytechnic. Each student must maintain an overall B average for all courses and for dissertation units completed for the doctoral degree.

Foreign language requirements, if any, are determined by 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 twelve years. Any extension of these periods requires the recommendation of the Guidance Committee and the approval of the Office of Research and Graduate Studies.

**GRADUATE CERTIFICATE PROGRAMS**

Polytechnic offers certificate programs in a number of specialized areas (see section “Curricula”). "Application for Graduate Admission" must be completed and the applicant must be formally admitted to the certificate program. A student in a certificate program who subsequently decides to earn a graduate degree must 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. An average of B or better in all courses is required. No courses applied to a certificate may be applied to other certificates. Requirements for certificates must be completed within three years.

**APPLICATION FOR DEGREE**

Formal application for the award of the degree must be filed by graduate and undergraduate students. Filing dates for each semester are published in the Schedule of Classes. Students who do not file by the published deadline dates become candidates for the next graduating class.

Applications for the B.S., M.S. and Engineer are available in the Office of the Registrar. Degrees are conferred at the spring commencement. Applications for the Ph.D degree are available in the Office of Research and Graduate Studies. Degrees are certified twice a year at the end of fall and spring semesters. Filing fees for diplomas are payable at the time of filing in the Office of the Bursar. If award of the degree is delayed, diploma fees are not charged again.

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

**THESIS AND DISSERTATIONS**

**Undergraduate Theses**

The purposes of the thesis is to apply the knowledge gained in the field of major interest and to familiarize the student with methods of planning, conducting and reporting research.

All students who plan to undertake a thesis project should report to the head of their major department for choice of a thesis topic at least one year prior to graduation. The head of the department will approve requests and appoint a thesis adviser. Students should contact their thesis adviser immediately and register for thesis at the next registration period. Thereafter, students must register for thesis every fall and spring (summers, with special permission) until the thesis is completed and the final grade is entered into the student's permanent record.

The thesis may be a dissertation upon a subject included in the student's courses of study. An account of original research, a report on a project or original design accompanied by an explanatory statement. 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 University.

**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 engineering 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 Office of Research and Graduate Studies 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 registration will obligate the student for full tuition and laboratory fees. Registration for the last unit is required until a final grade is submitted to the Office of the Registrar.

**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 Office of Research and Graduate Studies 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 left 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 Office of Research and Graduate Studies 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 Office of Research and Graduate Studies. 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 an 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. The publication must indicate, by footnote or otherwise, its basis is a Polytechnic dissertation.
<table>
<thead>
<tr>
<th>PRIZES AND AWARDS GIVEN AT GRADUATION</th>
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</thead>
<tbody>
<tr>
<td>WILLIAM R. ALLEN AWARD</td>
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<tr>
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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 University. Specifically, (1) the student’s educational records (with the exception of directory information) will be released to third parties outside Polytechnic only with the student’s written consent, (2) the student has the right to inspect his or her own individually identifiable educational records, (3) the student has the right to have the information contained in his or her individually identifiable educational records reviewed.

The Family Educational Rights and Privacy Act permits the release of directory type information to third parties outside Polytechnic without written consent provided students have been given the opportunity to withhold such disclosure. Polytechnic 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 University, degree. Currently registered undergraduates and graduate students may withhold directory information by requesting this in writing to the Office of the Registrar each semester.

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

CLASS STANDING

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

- Freshmen .................. 1-27 credits
- Sophomores ................ 28 credits plus
- Juniors ...................... 52 credits plus
- Seniors ..................... 95 credits plus

CREDITS PERMITTED

Undergraduates

Full-time. A student who takes 12 or more credits is categorized as full-time. The maximum course load for full-time undergraduate students is normally 19 credits. Students in special situations (such as graduating seniors or ROTC cadets) must receive permission from the head of their major department for any program above 19 credits. Students who register for more than 20 credits will be charged the per credit rate for additional credits or half credits.

International Students. International students on F-1 or J-1 visas are required to enroll in a full-time program of study each semester.

Part-time. Students registered for less than 12 credits per semester (except summer) are considered part-time students. Part-time students do not qualify for most financial assistance programs.

Summer and Intersessions. Students may register for summer courses, and for no more than 14 credits for the combined 12-week summer session. Six credits for a given summer term is considered full-time status, particularly for financial aid purposes. Courses taken during intersession are treated as if they were taken during the subsequent semester or summer session for purposes of student records and credit.

Graduates

Full-time. Registration for 12 units or more categorize graduate students as full-time. Students who register for more than 20 units will be charged the per unit rate for additional units or half units.

Part-time. Students registered for less than 12 units per semester (except summer) are considered part-time students. Part-time students do not qualify for most financial assistance programs.

GENERAL INFORMATION

COURSE WITHDRAWAL

Students may withdraw from a course or courses without academic penalty through the 10th week of the normal fall or spring semester. When the duration of the course varies, as in 6, 9 or 12 week courses, withdrawal must be filed before two-thirds of the session is completed. Withdrawals must be filed with the Office of the Registrar by 5:00 PM on Friday of the week indicated. In the case of a two week session, withdrawal must be filed by 5:00 PM of the seventh day. Students who file a course withdrawal form with the Office of the Registrar by scheduled 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 the Registrar in writing.

TOTAL WITHDRAWAL FROM THE UNIVERSITY

Students who withdraw completely during a semester in which they are registered must notify the Dean of Student Life or the Office of Research and Graduate Studies. No withdrawal is official unless a written form is approved and submitted to the Office of the Registrar. Mere absence from classes does not constitute official withdrawal, but will lead to failure grades of F recorded for the semester.

AUDITING COURSES (Graduate Students)

Graduate Students have the option of auditing courses instead of receiving units and grades for them. Regular
tuition is charged, and courses are treated as part of a full-time load. An AU notation is made on the student’s permanent record.

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

CREDIT BY EXAMINATION (Undergraduate Students)

Undergraduate students with an outstanding record or with specialized competence may establish a maximum of 18 credits toward the baccalaureate degree by passing comprehensive examinations. Each department determines the courses in which such an examination is available and the examination format. Students must obtain approval of the department giving the course and the department of major study.

A grade of B+ or better is required to achieve credit. Students who register or attend a course at the Polytechnic may not subsequently take the examination for credit for this course or for a course with similar content. No examination may be taken more than once.

A specified fee is paid to the bursar in advance of each examination. The course credits are posted on the permanent record without a grade, and do not count towards the minimum residence requirement for the bachelor’s degree or for a degree with honors.

In the area of foreign languages, those presenting their native tongue or the language in which they were schooled are excluded from credit for the first four semesters of work in that language.

VALIDATION CREDITS (Undergraduate and 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.

Permission to take such an examination must be recorded in advance on the student’s transfer credit evaluation form. The format of the examination is at the discretion of the department giving the course. Scheduling of the examination is by mutual agreement, but in no event later than one calendar year after the student begins studies at Polytechnic. A grade of C or better is required to validate the course credits for undergraduate students. A grade of B or better is required for graduate students. An examination may not be taken more than once. A student who registers in or attends the course at Polytechnic forfeits his right to take a validation examination.

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

TRANSCRIPTS

Polytechnic 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 students.

Official transcripts of the scholastic record of any student or graduate will be issued only upon 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 other properly authorized parties. In no case, however, can a student receive official copies 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.

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

COMPUTATION OF GRADE-POINT AVERAGE

Undergraduate Grading

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

<table>
<thead>
<tr>
<th>Grade</th>
<th>Point Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.0</td>
<td>Excellent</td>
</tr>
<tr>
<td>A-</td>
<td>3.7</td>
<td>Superior</td>
</tr>
<tr>
<td>B+</td>
<td>3.3</td>
<td>Good</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
<td>Good</td>
</tr>
<tr>
<td>B-</td>
<td>2.7</td>
<td>Good</td>
</tr>
<tr>
<td>C+</td>
<td>2.3</td>
<td>Passing</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>C-</td>
<td>1.7</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>D+</td>
<td>1.3</td>
<td>Deficient Passing</td>
</tr>
<tr>
<td>D</td>
<td>1.0</td>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>F</td>
<td>0.0</td>
<td>Failing</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>U</td>
<td>-</td>
<td>Unsatisfactory</td>
</tr>
</tbody>
</table>

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 or U has been assigned.

Grade-point averages are 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 grade 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 lower 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, when the earned letter grade is entered on the 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. Durations of these temporary grades are determined by instructors and usually do not extend beyond the end of intersession.

An I grade lapses into a grade of F if the student fails to complete 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 their field of special interest on their applications, it is expected and understood that some will change departments. 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 Office of Research and Graduate Studies. Such applications will require the approval of the departmental adviser. Students changing departments at the graduate level may be required to satisfy new conditions consistent with the requirements for the degree.

LEAVE OF ABSENCE

Undergraduates

A student wishing a leave of absence must 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 before 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 the Registrar. 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 requests, when approved by the Office of Research and Graduate Studies, will constitute assurance of readmission to the degree program. Forms for requesting a leave of absence are available in the Office of Research and Graduate Studies.

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

CONCURRENT ATTENDANCE

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

ACADEMIC STANDING

To remain in good standing, undergraduate students must maintain term and cumulative grade-point averages of 2.0 or greater. In addition, students 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 numbers of cumulative credits to be achieved by the close of each term of full-time study appear in Table I.
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</td>
<td>6</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>
</tr>
<tr>
<td>credits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>successfully completed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In calculating the number of successfully completed credits:
1. Credits undertaken for which the grade of F is earned count in calculation of total credits of enrollment. They do not, however, figure into the number of credits successfully completed.
2. Credits originally bearing the grade of F and repeated within one academic year will be recalculated using the second grade earned, thus 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. Credits with the grade of I that has not been changed by the professor of record will go to the grade of F.
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 minima in the same way as students pursuing a degree with a cumulative grade-point average of 3.4 are commended by the Dean of Students and placed on the honors list. This list is posted semi-annually for full-time enrollment and annually for part-time students. Only those who complete 12 semester hours or more during a regular academic semester (or academic year for part-time students) with a cumulative grade point average of 3.4 are eligible. Students who include project courses in their 12-credit-or-more programs are also eligible for the Dean’s List, provided that these courses represent no more than one-half of the credit load for a given period and all aforementioned requirements are met. The Dean’s List notation appears on student’s permanent records.

PROBATION

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

Students are placed on probation when semester and/or cumulative grade-point averages falls below 2.00. The status of continued probation is assigned when the grade-point averages remain below 2.00 for longer than one term. When the grade-point average and the number of credits successfully completed approaches the minimum level of satisfactory progress, students are required to seek the permission of the Dean of Student Life in order to register.

Students on 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 advisers and the Dean of Students. Students who are on continued probation must have permission to register. They may not be allowed to 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 Students 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 major department may disqualify a student at or above the minima 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 serious medical and personal disorders, must be documented and can lead to the waiver of these criteria for one term. Performance in the subsequent term must meet minimal standards. Such arrangements must be made in concert with the head of the major department and the Dean of Student Life.

TABLE II

<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 cumulative G.P.A.</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>1.67</td>
<td>1.78</td>
<td>1.88</td>
<td>1.95</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

ACADEMIC MONITORING

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

DEAN’S LIST

Undergraduate students who achieve grade point averages of 3.4 or better, with no failures or incompletes, are commended by the Dean of Students and placed on the honors list. This list is posted semi-annually for full-time...
CAMPUS LIFE

OFFICE OF STUDENT LIFE

The Office of Student Life is responsible for the operation and maintenance of student-oriented and student supporting programs and services. The office helps students obtain the maximal benefits from their training — academically, culturally and socially — and supplements and reinforces the educational programs by:

- Providing Freshmen Services, including orientation, academic monitoring, counseling/tutorial referrals, and other services as needed
- Providing services to guide students in obtaining the most satisfactory results in scholarship and personal adjustment
- Giving assistance to students 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 Polytechnic
- Keeping the student aware of the rules and policies of Polytechnic
- Administering the academic and disciplinary policies of Polytechnic

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 Polytechnic. The data measure retention patterns, and indicate the amount of time needed to complete undergraduate degrees at Polytechnic.

The initial cohort for the fall 1985 study was the group of first-time, full-time students who entered as freshmen in the fall of 1979.

Of that entering class, 56.2% received their Bachelor of Science degrees within four years; 54.9% graduated within five years; and 70% completed their degree within six years of their first term.

UNDERGRADUATE ORIENTATION

Orientation programs are planned for the beginning of each semester. Incoming students are introduced to the academic and social environments of Polytechnic. Informative sessions, advisement and activities related to student life are offered. New students are welcomed and assisted in making the transition from their former academic environment to Polytechnic as comfortable as possible. All new students are invited to participate in the New Student Overnight Trip, held annually at the beginning of the fall semester. All freshmen are strongly encouraged to take the freshmen seminar course, entitled "SL 101 Student Survival." This course provides freshmen with skills training as well as a continued orientation to college at Polytechnic.

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 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 a planning program for an advanced degree and to guide them in their professional advancement.

COUNSELING SERVICES

Polytechnic offers no psychological services, other than referrals to outside sources. Often students require counseling in dealing with 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 students need 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.

Special Services also 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.

Addressing the varied needs of the Polytechnic student is the primary goal of the Special Services Office. All tutorial, educational and counseling support services are provided free of charge. Because of the Office of Special Services is sponsored in part by a grant from the United States Department of Education, some students requesting assistance must first meet the federal eligibility guidelines.

TUTORING PROGRAMS (Freshmen Learning Center)

Freshmen showing failures or low grades at midterm are notified that tutoring is needed. 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 are prearranged schedules for students and tutors.
which stand for the entire semester, which generally lasts one hour a week per course. Students missing three sessions are dropped from the program. Improvement is monitored by evaluating the grades of students 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

All international students and scholars are REQUIRED to contact the international Students Office immediately upon arrival. Students must bring their immigration documents and passports with them for their initial meeting.

The Polytechnic University has enrolled international students in both graduate and undergraduate studies for many years. Students holding visas make up approximately 12% of the Polytechnic population and are an integral part of Polytechnic. Faculty and administrators are sensitive to the needs of international students and strive to meet them. Services for international students are coordinated by the Student Life Staff and are primarily housed in the Student Center on the Brooklyn campus. Information regarding immigration compliance, housing, health insurance, special events and referrals are available through the International Student Office in the Student Center.

For further information, consult those sections dealing with graduate and undergraduate admissions.

HANDICAPPED STUDENTS

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


CAREER SERVICES

The placement service for students functions as part of the educational offering 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 responsibility for deciding what, how, when and where they will provide for their future needs.

The primary function of Career Services is to help students learn how to locate suitable positions, decide whether to work or pursue graduate studies, and 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 career or job changes.

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 utilize its services fully.

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 Polytechnic, business, government and industry. Demand for graduating students and alumni is constant. Over 250 major companies come to campus to recruit students, and over five thousand interviews are conducted annually. During the past five years, the placement rate for Polytechnic graduates has averaged over 90%.

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 Polytechnic 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 a very important role in the development of the leadership and interpersonal abilities of an individual. Polytechnic 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 video game room, ping pong tables, student organization offices, lounge space, a six-foot TV screen, and administrative offices of some student life staff.

On the Long Island Campus, Grunman Hall, the Student Center houses a game room which contains video and pinball games, pool tables, and ping pong tables, the bookstore, Career Services Office, Resident Life Office, a darkroom, student organization offices, and the Office of the Associate Dean of Students.

There are approximately 70 student organizations. Each group is responsible for fulfilling the purposes 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 Polytechnic. The members of the Student Government are elected during campus-wide elections held every year. It is responsible for the administering of student fees, social and cultural programming, and other co-curricular events. There is a separate governing board on the Brooklyn and Long Island campuses.
PUBLICATIONS

A number of student-run publications exist at Polytechnic. There is a newspaper and a yearbook produced on both the Brooklyn and the Farmingdale campuses.

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.

ATHLETICS

For students who seek intercollegiate competition, Polytechnic maintains the following varsity teams for men: baseball, basketball, wrestling, judo, tennis, lacrosse, cross-country, and soccer. For women Polytechnic offers team competition in cross-country, judo, and volleyball.

All full-time undergraduate students who are in good academic standing are eligible for team membership, and are encouraged to participate. The University is a member of the NCAA (National Collegiate Athletic Association), the ECAC (Eastern Collegiate Athletic Conference), and the IAC (Independent Athletic Conference).

The Athletic Department also offers a wide range of intramural sports competition including touch football, basketball, handball, soccer, badminton, mini-marathons, paddleball, softball, tennis, and volleyball. These sports are open to all undergraduate and graduate students as well as the faculty and staff. Contests are held during club hours.

PROFESSIONAL AND DEPARTMENTAL SOCIETIES

Professional and technical societies are established in conjunction with the various departments 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 and Sororities

Six national fraternities, and one local sorority, are represented at Polytechnic. Some own or rent property in the Brooklyn area, with two offering live-in accommodations. The social fraternities not only administer an impressive array of social functions for their own members, but also serve the student body in many activities. These include the organization of blood donation drives, dances, and annual charity drive and handball, basketball and bowling tournaments.

On the Long Island 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 social, intellectual, religious, musical, cultural or athletic. Many have a long and distinguished history.

Honor Societies

On the basis of their superior records of academic and cocurricular achievements, 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 COCURRICULAR ORGANIZATIONS

Professional Societies
American Institute of Aeronautics and Astronautics
American Institute of Chemical Engineers
American Society of Civil Engineers
American Society of Mechanical Engineers
American Society of Metals
Association of Computing Machinery
Institute of Electrical and Electronic Engineers
Institute of Industrial Engineers
Society of American Military Engineers
Society of Automotive Engineers
Society of Physics Students
Society of Women Engineers

Student Organizations
Association of Latin American Students
Astronomical Society
Bolican (newspaper)
Celtic Society
Chess Club
Chinese Student Association
Christian Fellowship
Conflict Simulation Society
Demokritos (Greek Club)
Haitian Student Association
Innovations (yearbook)
International Student Association
Italian American Student Association
Jewish Student Union
Korean Student Association
Micro Computer Society
Musicians Guild
NARTU
National Society of Black Engineers
Pershing Rifles
Photography Club (Focus)
Polywog (yearbook)
Programmable Calculator Club
Radio Club
Resident Student Organization
Reporter (newspaper)
Robotics
Scabbard and Blade
Society of Arabic Students
Society of American Indian Students
Student Alumni Association
Student Information Center
Vietnamese Student Association
WPIV (radio station)

Fraternities and Sororities
Alpha Phi Omega
Lambda Chi Alpha
Pi Kappa Phi
Tau Delta Phi
Honor Societies
Chi Epsilon, civil engineering
Eta Kappa Nu, electrical engineering
Omega Chi Epsilon, chemical engineering
Phi 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 Xi, research
Tau Beta Pi, engineering

HOUSING

Residence life at Polytechnic is designed to provide students with comfortable places in which to live, grow and complete their education. There is a Coordinator of Residence Life who works with resident assistants on the Brooklyn campus and a Residence Facilities Manager on the Long Island campus.

Polytechnic students use the Residence Hall for studying, relaxing, sleeping and making friends. Students who take advantage of the Residence Hall programs can enrich their college years with a variety of experiences. They take part in tournaments, resident students organization functions, sports and many other activities.

Resident students on the Brooklyn campus are housed on two 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. There are no cooking facilities but an optional meal plan is 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 and a laundry room. There are no facilities for children or married couples. Off-campus housing is available in the surrounding area.

Each dormitory student is required by the Institute to have a full physical and health form filled out before moving into the residence hall or within the first week of residence.

Inquiries about housing should be made to the Office of Dean of Students on respective campuses.

To assure tranquility and appropriate living environment, all residents are expected to respect each other's privacy and rights. Inappropriate behavior is addressed through the following sanctions.

1. Verbal Warning
   A verbal warning is made to the student by a member of the Office of Student Life staff discussing the incident.

2. Written Warning
   An official written warning is sent to the student and discussed with the Office of Student Life staff members. The student is told that further violations will result in probationary action. A copy of the warning is put into the student's file for one year.

3. Probation
   A student is put on dormitory probation by a member of the Office of Student Life for a specific length of time. If involved in any additional incidents, this may result in possible removal from the dormitory. A copy of the probationary letter is put into student's file for one year.

4. Suspension Removal
   The Dean of Students convenes the Student Affairs Committee of the Faculty and action of the suspension or removal is discussed. The length of time of suspension or permanent removal is determined by the Committee.
CODE OF CONDUCT

The Polytechnic University of New York draws a diverse population in pursuit of honest inquiry and academic excellence. The education and human interchange that ensue are grounded in academic freedom and mutual respect. The rights and responsibilities contained in municipal, state and federal statues are provided and expected from all members of the Polytechnic community. The University 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 express and prior permission from the instructors involved in it. The following explanations clarify this for all students.

Written Work

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

Examinations

Students using or receiving unauthorized assistance from notes or from other students during examination, are in violation of academic regulations and are subject to academic discipline, including failure of credit for the course, probation, and dismissal from Polytechnic.

Laboratory Experiments

Although students may be permitted or required to cooperate with one or more fellow students in laboratory experiments, many are done independently; all require some independent work. For students to submit the results of others work as their own, or to accept unauthorized help in experiments, constitutes academic dishonesty.

I. RULES OF CONDUCT

A. All members of the Polytechnic 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 Polytechnic premises.

1. Conduct which violates such laws and ordinances on Polytechnic premises is subject to Polytechnic discipline and public sanctions as circumstances may warrant or dictate.

2. Conduct in violation of such laws and ordinances occurring off Polytechnic premises is ordinarily not subject to Polytechnic discipline unless such conduct:
   a. seriously affects the interests of Polytechnic or the position of members within the Polytechnic community, or
   b. occurs in close proximity to Polytechnic premises and is connected with offensive conduct on Polytechnic premises.

B. All members of the Polytechnic 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 Polytechnic.

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

3. Injury to Polytechnic property, real or personal.

4. Unauthorized access to or occupation of nonpublic areas on Polytechnic 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 or records.

C. Visitors, including invitees or licensees, shall at all times conduct themselves in a manner which is consistent with the maintenance of order on Polytechnic premises; their privilege to remain on Polytechnic property shall terminate upon breach of this regulation. Polytechnic in addition reserves the right, at its discretion, to withdraw at any time the privileges of invitees or licensees to be on Polytechnic premises. Trespassers have no privileges of any kind on Polytechnic property but are nonetheless 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 or trespassers). When administrative officers or members of the protection services of Polytechnic in their discretion determine that the privileges of invitees or licensees to be on Polytechnic premises should be withdrawn, they ask the invitees or licensees to leave the premises; the invitation or license shall thereby be terminated. If any person, whether initially trespasser, licensee or invitee, fails to leave Polytechnic premises promptly upon request, Polytechnic will use all reasonable means, including calling for assistance of the police, to effect removal.

B. Disciplinary Action. Members of Polytechnic who are charged with violations of Polytechnic rules set forth in Section I above are subject to appropriate disciplinary action as follows:

1. Students
   a. Disciplinary actions are taken by the Student Affairs Committee of the Faculty and the Office 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 Students are requested. That person contacts all parties involved, collects facts and requests 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 which affect the general operation and policies of Polytechnic are addressed at administrative hearings. At that time, persons may personally introduce relevant information in support of particular positions. Persons may also have advisers present. Such deliberations are taken by the Student Affairs Committee. The recommendations of that body may be appealed to the Provost.

2. Faculty Members
   a. When faculty members are charged with violations of these rules, efforts are made to resolve matters 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 matters cannot be resolved as provided in the preceding paragraph, disciplinary actions 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 applies.
      ii. If the faculty member does not have continuous or permanent tenure, the case is referred to a special committee of the faculty designated for that purpose. The special committee adopts its own rules of procedure. It has the authority to impose penalties other than dismissal and to recommend dismissal.

3. Polytechnic Staff:
   Administrative Officers and Other Employees
   When members of the Polytechnic staff, other than faculty members, have been charged with violations of Polytechnic rules, the charges are considered and determined administratively in accordance with established practices of Polytechnic. If the person against whom the charges have been made is both an administrative officer and a faculty member, the case is governed by this section unless the conduct was of a nature to cast doubt upon the person's continued qualifications for service on the faculty; in the latter event, disciplinary action proceeds in accordance with Section II-b-2, above.

4. Student Organizations
   If a student organization is charged with a violation of Polytechnic rules, the charges are considered by the Dean of Students, and the penalty assessed is in accordance with those outlined below.

III. PENALTIES
   Penalties for violation Polytechnic rules which may be imposed upon members of the Polytechnic community include the following:
   1. Reprimand
   2. Censure
   3. Removal of privileges
   4. Suspension
   5. Dismissal or expulsion
   6. Discontinuance of permission for student organizations to operate on campus
   7. Other sanctions deemed appropriate

Students receive no tuition or fee refunds for semesters during which they are suspended or expelled for disciplinary reasons.

ALCOHOL

Polytechnic University of New York does not condone the use of alcohol on campus. Polytechnic strictly adheres to the New York State law requiring individuals to be at least 21 years of age to drink.

All student groups wishing to hold events where beer or wine is served must have permission of the Dean of Students.

DRUG ABUSE

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

HAZING

Polytechnic complies with Section 6450 of the Education Law of the State of New York (As amended in 1990). Accordingly, any actions or situations which recklessly or intentionally endanger mental or physical health or involve the forced consumption of liquor or drugs or purposes of initiation into or affiliation with any organizations is prohibited.

Code of Conduct is subject to change based on annual review.
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 (MA224) 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 PROGRAM

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 covered includes the instrumentation to acquire physiologic data and the techniques to analyze and process such data.

Bioengineers bring new viewpoints 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 systems. 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, bio-engineers provide the intellectual link between engineering and the life sciences, a role 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 equivalents) 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 seniors tear. Students from other schools take these courses or show equivalent preparation.

The master's programs consist of 36 units: 6 in mathematics, 18 in bioengineering, 6 in research and 6 in electives. This 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>CM 122</td>
<td>Organic Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CM 164</td>
<td>Physical Chemistry of Living Systems</td>
<td>3</td>
</tr>
<tr>
<td>LS 105</td>
<td>General Biology I</td>
<td>4</td>
</tr>
<tr>
<td>BE 201-202</td>
<td>Systems Approach to Biomedicine I, II</td>
<td>4</td>
</tr>
</tbody>
</table>

MA 001 Review of Calculus 0

GRADUATE REQUIREMENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE 600</td>
<td>Physiology Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BE 602</td>
<td>Clinical Techniques Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>BE 603</td>
<td>Biophysics I</td>
<td>3</td>
</tr>
<tr>
<td>BE 610-611</td>
<td>Physiology for Bioengineers</td>
<td>6</td>
</tr>
<tr>
<td>BE 621</td>
<td>Instruments and Measurements in Physiological Systems</td>
<td>3</td>
</tr>
<tr>
<td>BE 961-962</td>
<td>Colloquium in Bioengineering</td>
<td>6</td>
</tr>
<tr>
<td>Electives in Mathematics (chosen with the approval of the adviser)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Electives in Bioengineering</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>BE 965</td>
<td>Project</td>
<td>6</td>
</tr>
</tbody>
</table>

Total 36

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

Total 58
BIOENGINEERING

UNDERGRADUATE COURSES

BE 201-203 Systems Approach to Biomedicine I, II each 2:0:2

GRADUATE COURSES

BE 600 Physiology Laboratory 0:4:3
Studies of physiological specimens. Microscopic studies of tissue, nerve and muscle. Animal studies. Co/Prerequisite: BE 610

BE 602 Clinical Techniques Laboratory 0:4:3
Laboratory tests and measurements in biological specimens and relation to pathological states. Determination of fluid properties—viscosity, refractive index, etc. Characteristics of pH meters, pH determinations, colorimetry, spectrophotometry, fluorimetry, flame photometry. Separation techniques—centrifuge, chromatography, electrophoresis. Tracer techniques. Co/Prerequisites: LS 105 and BE 610 and CM 164 or equivalent. Also listed under PH 635

BE 603 Biophysics I 2:v:0:3
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. Compartimental analysis, models, trace analysis. Prerequisite: BE 201-202 or equivalent and Co/Prerequisites: LS 105 and CM 154 or equivalent. Also listed under PH 636

BE 604 Biophysics II 2:v:0:3
Transport processes in and models of specific organs. Application of radionuclides and dyes for imaging. Nerve conduction with a detailed discussion of the Hodgkin-Huxley and current models. Prey-predator interactions on the cellular level, in radioimmunoassays, and in population control. Prerequisite: BE 603. Also listed under PH 637

BE 605 Radiation Physics with Biological and Medical Applications* 2:v:0:3
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, radiation safety levels, effects of acoustical, microwaves, and thermal radiation. Prerequisite: PH 355 or equivalent. Also listed under PH 637

BE 610-611 Physiology for Bioengineers I, II each 2:v:0:3
Intensive course in human physiology. Overall organization of the body: colon, tissue, cells, organs, structure, fluids. Properties and transportation of body fluids; renal function; cardio-pulmonary, nervous, and gastrointestinal systems. BE 610 Prerequisites: CM 122 and LS 105 or equivalent. BE 611 Prerequisite: BE 610.

BE 612 Advanced Physiology Laboratory* 1:0:5
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 2:4:0:3
Theoretical and practical aspects of measurement problems in physiological systems. Volume conductors: microelectrodes, technique for acquiring body-generated signals. Multi-channel screening systems: EMG, EEG, EKG. Readout devices and computer interface; digital instrumentation; telemetry. Analysis and digital computer simulation of biological systems. Prerequisites: BE 201-202 and Co/Prerequisite: LS 105.

BE 623 Minicomputer Instrumentation for Scientific Research* 1:2:3
Fundamentals of digital electronics and minicomputers; computer-automated laboratory instrumentation; programming and interfacing and 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* 2:4:0:3
Fundamental basics of biomechanics interpreted in terms of the human engineering and engineering mechanics. Applications to industrial and medical problems. Significant anatomical, kinetical and physiological considerations. Examination of applications to industrial as well as medical problems. Also listed under ME 651

BE 670 Biosystems* 2:4:0:3
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: instructor's approval. Also listed under SS 912

BE 673 Sensation and Perception* 2:4:0:3
Review of different sensory systems: vision, audition, taste, smell, touch, temperature sensitivity, vestibular, kinesthetic senses and their relation to nonsensory controlling stimuli, techniques of obtaining psycho-physical 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 the instructor. Prerequisite: SS 199 or equivalent or instructor's permission. Also listed under SS 914

BE 692 Neurophysiology* 2:4:0:3
An in-depth discussion of basic nerve cell physiology covering such topics as 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* 2:4:0:3
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 central nervous system disorders, etc. Topics will vary from semester to semester and course may be taken for repeated credits. Prerequisite: LS 106 or BE 611 or instructor's permission. Also listed under LS 601
BE 695 Physiological Psychology* 2.5:0:3
Review of physiological bases and correlates of behavior. Physiology of sensory systems, emotions, motivations and electrophysiological correlates of learning. Prerequisite: SS 198 or BE 111 or instructor's approval.
Also listed under SS 913

BE 741 Bioengineering Metallurgy I* 2.5:0:3
Also listed under MT 727

BE 742 Bioengineering Metallurgy II* 2.5:0:3

BE 800 Selected Topics in Bioengineering* 2.5:0:3
Topics of special current interest in bioengineering as announced in advance of a particular semester offering. Prerequisite: adviser'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 000 for details.

THESIS, COLLOQUIUM AND INTERNSHIP

BE 981-982 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
Assignments 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. Projects 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 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. Blosser, 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
Biorheology; social technology

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

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. Ackerburg, 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

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
BIOENGINEERING

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
CHEMICAL ENGINEERING

Students of Chemical Engineering are taught to develop knowledge and analytical skills to bridge the technological gap between scientific advances and the economical production of new and useful products.

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

Students may choose 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. Opportunities 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 solid 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 which enables the graduate to select a professional career from an extremely broad spectrum of opportunities. Graduates are prepared to take employment in 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 undergraduate degree programs at two campuses, Brooklyn and Long Island, with identical curricula and courses.

Students wishing to specialize in certain subject areas may do so through judicious selection of technical electives. Chemical engineering students may be particularly interested in the medical-related field, in environmental problems, in computer applications or management. For example, students interested in medical or biosystems might choose technical elective courses such as LS 105, LS 115, BE 201, BE 206, BE 610, and BE 603, while those interested in environmental studies might choose SS 182, LS 105, LS 140, CE 340, CE 341, CE 770, CE 342 and CH 752. A management emphasis might be developed by choosing MG 300, SS 251 & 252, IE 252, IE 327 and MG 601. Similarly, an emphasis in computer sciences could be arranged. Specializations can be developed with departmental advisers.

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

Polytechnic requires a 2.0 minimum average for graduation. Students must meet the academic standards of the department. For students to advance to the senior year, a 2.0 grade average must be maintained in chemical engineering courses CH 123, CH 124, CH 220, CH 221, CH 241, CH 251; the same course must not be failed twice. Students who do not meet these requirements will not be allowed to register for senior courses. All listed prerequisites must be satisfied before the students are permitted to enroll in chemical engineering courses.
CHEMICAL ENGINEERING

Typical Course of Study for the Bachelor of Science Degree in Chemical 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.</td>
<td>Subject</td>
<td>Cl.   Lab. Cr.</td>
<td>No.</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4     0   4</td>
<td>MA 102</td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
<td>3     0   3</td>
<td>PH 102</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2½  0  2½</td>
<td>CM 102</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab I</td>
<td>0     1½  ½</td>
<td>CM 112</td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing and the Humanities</td>
<td>3     0   3</td>
<td>CS 100</td>
</tr>
<tr>
<td>SS 104</td>
<td>Main Themes in Contemporary World History</td>
<td>3     0   3</td>
<td>HU 200</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>0     2   0</td>
<td>PE 102</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         | Organic Chem. I | 3     0   3   | CM 161     | Physical Chemistry I | 3     0   3    |
| CM 124         | Organic Chem. Lab I | 1½  5   2 | CM 123     | Organic Chem. II | 3     0   3    |
| PE 103         | Physical Education III | 0     2   0    | PE 104     | Physical Education IV | 0     2   0    |

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     | Mult. Sep. Proc. | 3     0   3    |
| CM 162         | Physical Chemistry II | 3     0   3    | EE 370     | Princ. Elect. Eng. | 3     0   3    |
| CH 351         | Proc. Dyn. & Control | 3     0   3   | EE 374     | Instrument. Lab. | 0     3   1    |
| CH 381         | Proc. Design I | 3     0   3  | Hum./Soc. Sci. elective | 3     0   3 |
|                | Technical elective | 3     0   3    |              | Technical elective | 3     0   3    |
|                | Free elective | 3     3    | | | |
|                |                | 17     | | | |

Senior Year

| CH 301         | Ch. E. Lab I | 0     6   2    | CH 302     | Ch. E. Lab II | 0     6   2    |
| CH 322         | Chem. React. Eng. | 3     0   3   | CH 271     | Eng. Materials | 3     0   3    |
| CH 351         | Proc. Dyn. & Control | 3     0   3   | CH 382     | Proc. Design II | 3     0   3    |
| CH 381         | Proc. Design I | 3     0   3  | Hum./Soc. Sci. elective | 3     0   3 |
|                | Technical elective | 3     0   3    |              | Technical elective | 3     0   3    |
|                |                | 4     | | | |
|                |                | 18    | | | |

Total credits required for graduation: 136

See item a under "Electives" on page 52.
See item b under "Electives" on page 53.
See item c under "Electives" on page 53.

ELECTIVES

Elective courses are chosen in consultation with the chemical engineering undergraduate adviser according 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 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 noncredit course before taking HU 101 (or HU 103). All students must also elect at least 15 credits in humanities and social sciences in addition to the above 9 credits.

At least 18 of the credits students select in the humanities and social sciences must meet the requirements of the Accreditation Board for Engineering and Technology (ABET). These credits may not include skills-oriented courses such as technical writing, public speaking, or English as a second language. Courses in literature, foreign languages, history, economics, and others are acceptable. Students should consult their adviser to ensure that these criteria are met.

Students should select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religions in the Department of Humanities, or economics, history, anthropology, or psychology in the Department of Social Sciences) and elect a number of courses in this concentration in consultation with their adviser. A modern language may be chosen as a suitable concentration, but students without prior knowledge of the language must plan to devote at least 12 credit hours to it.
For the remaining credits in the humanities/social sciences requirement, students should select courses in areas other than that of concentration. Additional courses in humanities and social sciences may be taken as free electives.

b. A total of 17 credits of technical electives is necessary. In fulfilling this requirement, the student must choose at least 3 credit hours of mathematics, 3 credit hours of chemistry or biosciences and 6 credit hours of chemical engineering electives from an approved list available in the chemical engineering office. The remaining 5 credit hours may be taken in any advanced level technical area in consultation with the departmental adviser.

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

**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 or free electives.

### GRADUATE PROGRAM

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

The Departments of Chemical Engineering and Chemistry jointly offer programs leading to degrees of master of science and doctor of philosophy in polymer science and engineering. (See page 36.)

A degree in chemical engineering is generally required for admission to graduate study. An applicant who has earned a bachelor's degree from a foreign institution is required to submit Graduate Record Examination and TOEFL scores. Students 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 as either a terminal course for development and advanced design, or as a research degree giving preliminary graduate training for the doctorate in chemical engineering.

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

The doctor of philosophy in chemical engineering degree program provides advanced graduate study and research for qualified students 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>CH 631-632</td>
<td>Transport Phenomena I, II</td>
<td>6</td>
</tr>
<tr>
<td>CH 771-772</td>
<td>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 821</td>
<td>Process Dynamics and Control</td>
<td>3</td>
</tr>
<tr>
<td>CH 991-992</td>
<td>Seminar in Chemical Engineering</td>
<td>0</td>
</tr>
</tbody>
</table>

Project/Thesis Option

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</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>or</td>
<td>CH 997</td>
<td>Master's Thesis</td>
</tr>
<tr>
<td>Electives (including 6 units chosen from CH 600 to CH 910)</td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

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

To meet graduation requirements, students may not obtain grades of C (or lower) in more than three required subjects listed above, including required courses retaken for purposes of improving grades. This requirement is in addition to Polytechnic's requirements for master's degrees.

### 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 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 are obliged to satisfy these deficiencies before enrollment in the engineering program.

Candidates for the degree of engineer in chemical engineering plan their programs 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 I</td>
<td>3</td>
</tr>
<tr>
<td>Chemical Engineering electives—chosen from CH 641, CH 721, CH 732, 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 998</td>
<td>Chemical Engineering Design Project</td>
<td>9</td>
</tr>
<tr>
<td>CH 991-992</td>
<td>Seminar</td>
<td>0</td>
</tr>
</tbody>
</table>

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CHEMICAL ENGINEERING

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

Upon completion of the design project the candidate must take an oral examination before a faculty committee. The examination focuses on the subject of the project; its scope is not limited, and the candidate is examined in the broadest 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 a guidance committee appointed by the office of Research and Graduate Studies. The program is planned to give the student thorough chemical engineering background accompanied by study of a minor field chosen by the candidate. The student must pass a comprehensive qualifying examination in chemical engineering, exhibit a reading knowledge in one 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 summer sessions, until it is completed and accepted. Of the 90 units, a minimum of 30 units must be taken at Polytechnic. A minimum of 48 graduate units beyond the bachelor's degree (not including Ph.D. thesis) in chemical engineering subjects are required, of which at least 18 units must be taken at Polytechnic. A minor is required within a science or engineering department and should consist of at least 12 credits. Attendance is required at chemical engineering seminars for at least four semesters. All students must maintain overall B averages 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 Reactor Design I</td>
<td>3</td>
</tr>
<tr>
<td>CH 782</td>
<td>Chemical Reactor Design II</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 information outlining procedures and requirements, which is available from the office of the department head.

UNDERGRADUATE COURSES

CH 123 Chemical Process Analysis I 2:0:2

CH 124 Chemical Process Analysis II 2:0:2
Continuation of studies of material and energy balances. Elementary thermodynamics and energy balances. Heats of reaction, solution and mixing. Combined energy and material balances. Computer methods. Prerequisite: CH 123.

CH 220 Transfer Operations I 4:0:4
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 4:0:4
Continuation of theory of transfer 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 3:0:3
Unified treatment of separation processes utilizing the multi-stage model and mass and energy balances, e.g., absorption, extraction, distillation. Equilibrium stages, 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 4:0:4
First and second laws of thermodynamics, open and closed systems, thermodynamic properties of materials; generalized correlations for real fluids and multicomponent systems. Chemical potentials and their uses in phase and chemical reaction equilibria. Prerequisites: CM 161 and CH 124, or adviser's approval.

CH 271 Engineering Materials 3:0:3
Structures, properties and uses of polymers and metals as engineering materials. Crystal structures, defects, heat treatments, corrosion and its prevention. Manufacture and processing of polymers. Mechanical behavior of polymers and their thermal and electrical properties. Prerequisites: CM 162, CH 322, CH 123 and CM 124.

Also listed under MT 420

CH 301-302 Chemical Engineering Laboratory I, II each 0:6:2
Experimental studies of operations in chemical engineering. Laboratory projects on unit operations, transport processes, thermodynamics, reaction kinetics, process instrumentation, process dynamics and controls. Design and conduct of experiments, interpretations of results, preparation of engineering reports. Data analyses done with computers. 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 theories. Process systems analyses via transient and frequency response methods; control systems designs. Analog computer simulations. Prerequisites: CH 221, CH 241, MA 104, or adviser’s approval.

CH 381 Process Design I 3:0:3
Syntheses and designs of chemical processes, with considerations of site and process selection processes economics, materials of construction, data requirements and acquisition flow sheeting and subsystems. Computer utilized. Case studies. Prerequisite: CH 241 and Co/Prerequisite: CH 351.

CH 382 Process Design II 3:0:3
Designs 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 variable credit to max. of 3 each
Independent work in areas of interest in chemical engineering selected by students and faculty supervisors. 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 381-382 Bachelor’s Thesis in Chemical Engineering variable credit
Original investigations of problems in chemical engineering. A thorough search of the literature required. Special apparatus constructed as required for experimental work.

CH 386 Chemical Engineering Internships 3 credits
Supervised, creative engineering experiences of at least two months’ duration, typically taken during the summer, culminating in written and oral reports presented to the industrial and faculty supervisors. Faculty visitations and conferences during internships are 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 2½:0:3
Studies of the important chemical industries, their processes and products. Effects of process variables on end products and needs for variations in properties of products as determined by market demands. Interlocking chemical industries. Product planning and marketing. Prerequisite: instructor’s permission.

CH 612 Chemical Processes and Project Evaluations 2½:0:3
Analyses of designs and operations 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 designs of chemical plant pumping, process piping insulation heat transfer and recovery systems, as well as various mass transfer operations such as distillation, gas absorption, stripping and liquid extraction. Prerequisite: CH 361 or equivalent.

CH 615 Applied Mathematics in Chemical Engineering 2½:0:3
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 250 or MA 531 or instructor’s permission.

CH 625 Design of Clean Rooms 2½:0:3

CH 631-632 Transport Phenomena I, II each 2½:0:3
Fundamental concepts of momentum, energy and mass transport; transport in stationary and flowing systems, steady-state and transient conditions. Elementary Cartesian vector and tensor analyses; 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* 2½:0:3

CH 672 Fundamentals of Biochemical Engineering 2½:0:3

CH 721 Mass Transfer Operations* 2½:0:3
Unified treatments of mass transfer operations such as distillation, absorption and extraction. Phase equilibrium 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 752 Air Pollution Engineering Control* 2½:0:3
Pollutant emissions control; analysis of pollutant properties, concentrations and boundary conditions; absorbptive and reactive recovery processes for moving and stationary sources; formation and removal of gaseous oxides (NOx, SOx, CO, etc.) and of aerosols and other particulates. Prerequisite: adviser’s approval. Also listed under CE 758

CH 766 Process Heat Transfer* 2½:0:3
Thermal design of industrial heat exchangers, including condensers and forced and natural circulation reboilers; process design of fired heaters; optimum uses of extended surfaces; heat transfers and power requirements of agitated jacketed vessels. Prerequisite: instructor’s permission.
CHEMICAL ENGINEERING

CH 771 Chemical Engineering
Thermodynamics I 2 1/2:0:3
Laws of thermodynamics; conditions for thermodynamic equilibrium; use of equations of state; the principle of corresponding states to determine changes in thermodynamic properties for pure substances and mixtures. Chemical potentials, standard states, ideal solutions, introduction to chemical and phase equilibria. Prerequisite: CH 251 or equivalent.

CH 772 Chemical Engineering
Thermodynamics II 2 1/2:0:3
Advanced treatment of chemical and phase equilibria, phase rules, and Gibbs-Dunham equation, non-ideal solutions, stability of thermodynamic systems, osmotic pressures, surface tensions, thermodynamic equilibrium in potential fields, introduction to irreversible thermodynamics. Prerequisite: CH 771 or equivalent.

CH 773 Chemical Reactor Design I 2 1/2:0:3
Kinetics of complex homogeneous and heterogeneous reactions: determination of kinetic parameters; effects of transport processes; catalyst deactivation. Analysis and design of reactors: ideal reactors, effects of nonideal flow; fixed-bed, fluidized-bed and multiphase reactors. Prerequisite: CH 322.

CH 774 Chemical Reactor Design II 2 1/2:0:3
Design techniques for industrially important reactor situations and advanced methodologies for complex reaction analysis.

CH 781 Chemical Reactor Design I 2 1/2:0:3
Kinetics of elementary steps (adsorption, surface reaction, desorption) and overall catalytic reactions: uniform and nonuniform surfaces, structure sensitivity, metal-support interactions, transport effects. Characterization of catalysis: preparation methods, analytical techniques. Prerequisite: CH 781 or equivalent.

CH 791 Electrochemical Engineering* 2 1/2:0:3
Theories and measurements of reversible and irreversible electrochemical processes at metal-electrolyte interfaces, Thermodynamics, kinetics, mass transport, mixed potential theories, passivation. Modern experimental techniques. Electrochemical energy conversion devices (batteries and fuel cells). Prerequisite: CM 162 or equivalent.

CH 784 Heterogeneous Catalysis* 2 1/2:0:3
Kinetics of elementary steps (adsorption, surface reaction, desorption) and overall catalytic reactions: uniform and nonuniform surfaces, structure sensitivity, metal-support interactions, transport effects. Characterization of catalysis: preparation methods, analytical techniques. Prerequisite: CH 781 or equivalent.

CH 790-901 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 Resources 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 817 Introduction to Polymer 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, polystyrene, acrylics and engineering plastics are discussed. Thermosetting materials to be covered include: phenolics, epoxies, unsaturated polyesters, amionoplastics, polyurethanes and silicones. Prerequisite: CM 123 or equivalent.

CH 821 Polymer Processing 2 1/2:0:3
Applications of engineering principles of polymer processing. Studies of non-Newtonian polymeric systems. Extrusion theories and applications. Discussion of problem-solving in compression, transfer and injection molding, thermforming and plasticizing, as well as other polymer engineering processes. Prerequisites: CH 220 and CH 221 or instructor's permission.

CH 822 Polymer Processing Laboratory 0:4:0
Laboratory studies 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 821.

CH 824 Polymerization Reaction Engineering 2 1/2:0:3
Principles of polymerization reactions, such as chain polymerization and heterogeneous polymerization reactions, from the engineering point of view, including mixing and thermal effects. Mathematical modeling techniques for describing molecular weight moments, copolymer composition and sequence distribution. Principles of polymer reactor design. Model parameter estimations and reactor controls. Prerequisite: CH 781 or equivalent.

CH 828 Engineering Properties of Polymers 2 1/2:0:3
Studies of mechanical properties and structures of solid polymers. Viscoelastic theories and responses of amorphous, crystalline and composite materials in stress-strain tests, creep, stress relaxation and dynamic tests. Effects of orientation, and previous history on mechanical behavior. Prerequisites: CH 915, CM 771.
CH 928  Polymer Composites  2½:0:3
Comprehensive coverage of production, properties and durability of polymer composites. Emphasis is on fiber-reinforced thermosets. Fundamentals of chemical compositions, cure kinetics, processing, viscoelasticity and fracture mechanics will be discussed. Behavior of composites in service will be analyzed in terms of their structures. Prerequisites: CH 921, CH 926.

CH 933  Coatings Technology  2½:0:3
Chemistry, manufacture and applications of organic film formers; solvents and solubility principles; mechanisms and methods of film application; formation, conversions. Chemistry manufacture and applications of pigments. Principles and methods of pigment dispersion and coatings preparation, including influences of rheology and surface chemistry. Principles of formulation of important paints and clear coatings. Specifications and test methods for coatings. Prerequisite: CM 123 or equivalent.

CH 940-941  Selected Topics in Polymer Science and Engineering I, II*  each 2½:0:3
Topics of special interest in polymeric materials as announced in advance of particular semester offering. Prerequisite: adviser's approval.

PROJECTS, THESSES AND SEMINARS

CH 902  Guided Studies in Chemical Engineering  6 units, each 2 units
Selections, analyses, solutions and presentations of engineering reports of problems in processes or equipment design, thermodynamic studies or correlations, or other fields of chemical engineering practice under supervision of staff member. Conferences scheduled. Master's degree candidates required to submit three unbound copies of typewritten reports to advisers 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
Selections, analyses, solutions and presentations of comprehensive reports of problems involving polymeric materials, such as polymer synthesis, processing, evaluations and equipment designs. Supervision by staff members. Conferences scheduled. Master's degree candidates required to submit three unbound copies of typewritten project reports to advisers one week before last day of classes. Prerequisite: degree status.

CH 997  Thesis for Degree of Master of Science in Chemical Engineering  9 units, each 3 units
Theses for master's degree in chemical engineering should give results of original investigations of problems in chemical engineering or application of physical, chemical, or other scientific principles to chemical engineering. Theses may involve experimental research, theoretical analysis, and design projects. Master's degree candidates required to submit four typewritten unbound thesis copies to advisers before or on seventh Wednesday prior to commencement. Prerequisite: degree status.

CH 998  Chemical Engineering Design Projects  9 units, each 3 units
Engineering analyses, synthesis, optimization, and design of processes or novel equipment. Projects require original individual work. Evaluations of results, uses of engineering judgment and excellence in reporting emphasized. Supervision by staff members. Conferences scheduled. Doctor's degree candidates required to submit five unbound typewritten project report copies to advisers before or after the seventh Wednesday. Prerequisite: degree status.

CH 999  Dissertation for Degree of Doctor of Philosophy in Chemical Engineering  30 units, each 3 units
Dissertations must give results of independent investigations of problems in chemical engineering and may involve experimental and/or theoretical work. Theses must show ability to do creative work and that original contributions have been made to chemical engineering, which are worthy of publication in recognized journals. Candidates required to take oral examinations on subjects of theses and related topics. Doctor's degree candidates required to submit five unbound thesis copies to advisers before or on the seventh Wednesday prior to commencement. Prerequisites: degree status and a qualifying examination on quantitative aspects of chemical engineering.

FACULTY

Allan S. Myerson, Associate Professor and Head of Chemical Engineering
B.S., Columbia University; M.S., Ph.D., University of Virginia
Crystalization, mass transfer, biochemical Engineering

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

Robert F. Benenati, Professor 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

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
CHEMICAL ENGINEERING

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., 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

Mohammad M. Ataai, Assistant Professor of Chemical Engineering
B.S., M.S., Tufts University; Ph.D., Cornell University
Biotechnology; Biochemical Engineering

John R. Battler, Assistant Professor of Chemical Engineering
B.S., M.S., Georgia Institute of Technology; Ph.D., Rice University
Thermodynamics, Process Control

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

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

ADJUNCT FACULTY

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

EMERITUS FACULTY

Paul F. Bruin, 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 processes, 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, Unit operations, laboratory information
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.

Faculty members participating in the chemical physics program are currently engaged in research in the following areas:

- Atomic and molecular dynamics
- Imaging sciences
- Infrared and Raman spectroscopy
- Laser chemistry and spectroscopy
- Medical physics
- Microparticle photophysics
- Photoelectrochemistry
- Polymer photochemistry and photophysics
- Solid state chemistry
- Statistical mechanics
- Surface and condensed matter physics
- X-ray crystallography

Doctoral research in chemical Physics involves working closely with a faculty member on a research project in areas such as those listed above.

Students normally enter the program with undergraduate degrees in chemistry, physics or mathematics. 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>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>
<tr>
<td>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:

- MA 260 Vector analysis and Partial Diff. Eqs. 4
- PH 313-314 Introduction to Theoretical Physics 6

Students with baccalaureate degrees in physics:

- CM 161-162 Physical Chemistry I, II 6
- CM 601 Inorganic Chemistry 4½
- Thesis, project and/or electives chosen from chemistry, physics, mathematics 8-11

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. A satisfactory pass is required.

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>CM971-972</td>
<td>Chemistry Colloquium</td>
<td>0</td>
</tr>
<tr>
<td>or PH901-901</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>

and one of the following:

- CM998/PH999 Thesis in Chemical Physics at least 12
- Electives* at least 21

- CM998 PH 999 Project in Chemical Physics at least 6
- Electives* at least 27
- or Electives* at least 33

* To be chosen from approved courses in chemistry, mathematics and physics in consultation with adviser.
‡ 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. Students are expected to pass examinations which form part of those regularly given to graduate students in the Departments of Chemistry and Physics.

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 when applying for admission to graduate school or later. Application forms, as well as additional information, are available from the Office of Research and Graduate Studies.

FACULTY INTERDEPARTMENTAL COMMITTEE

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

*Terje Kjeldaas, Jr., Professor and Head of Physics

William H. Starnes, Professor and Head of Chemistry

*Eli 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

Patrick T. Cahill, Professor of Physics

Hellmut J. Juretschke, Professor of Physics

Norman C. Peterson, Professor of Chemistry

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

Peter Hanggi, Assistant Professor of Physics

Donald M. Schleich, Associate Professor of Chemistry

*Ex officio
Chemistry is concerned with our knowledge of the structures, properties and reactions of matter and our evolving theories to explain our observations, predict chemical behavior and suggest experiments.

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 determinations of composition, and physical chemistry, which seeks understanding of matter, including chemical bonds and molecular interactions. These classical fields have overlapped increasingly, and several inter-disciplinary fields are now of great importance: biochemistry, electrochemistry, photochemistry, polymer chemistry, solid state chemistry, and chemical physics.

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

Staff members conduct and supervise research at undergraduate, graduate, and postdoctorate 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.

Participation of undergraduates in optional research activities provides them with both stimulus and good preparation for graduate school or professional positions.

The department offers programs leading to 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 Departments of Physics and Chemical Engineering.

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, flexible courses of study in both departments. The program leads to degrees of master of science and doctor of philosophy. (For details, see special listing.)

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

For students majoring in chemistry, the Department of Chemistry provides curricula which go beyond the requirements of the American Chemical Society for professional training. Courses offered are designed to prepare students for graduate studies or work in industry. Students may elect the thesis option or the no-thesis option in either chemistry or the biochemistry option (see detailed curricula).

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

Requirements for the Degree of Bachelor of Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CM 101, 102, 108, 109, 111, 112, 118-120, 122-125</td>
<td>45</td>
</tr>
<tr>
<td>161, 162, 175, 501, 504, 507</td>
<td>3</td>
</tr>
<tr>
<td>Advanced Chemistry</td>
<td>3</td>
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<tr>
<td>*Thesis Research (CM 390-394)</td>
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<tr>
<td>CS 100</td>
<td>2</td>
</tr>
<tr>
<td>MA 101-104</td>
<td>2</td>
</tr>
<tr>
<td>PH 101-103</td>
<td>10</td>
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</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 and social sciences.

To graduate, students must demonstrate knowledge of French, German or Russian equivalent to fourth semester courses. This may be done by passing appropriate courses or special examinations administered by the humanities department.

*Students electing thesis research are required to submit a written thesis prior to graduation. Students may elect a no-thesis option and select ten credits of advanced chemistry courses in consultation with an advisor.
Curriculum for the Bachelor of Science Degree 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>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
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<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2 ½</td>
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<tr>
<td>CM 111</td>
<td>General Chemistry Lab I</td>
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<td>MA 101</td>
<td>Calculus I</td>
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<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
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<td>0</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
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</tbody>
</table>

Sophomore Year

| | Hours/Week | | |
| CM 122 | Organic Chemistry I | 3 | 0 | 3 |
| CM 124 | Organic Chemistry Lab I | 3/10 | 6 | 2 |
| | Hum./Soc. Sci. electives | 6 | 0 | 6 |
| MA 103 | Calculus III | 3 | 0 | 3 |
| PH 103 | Introductory Physics III | 2 | 1 ½ | 3 |
| PE 103 | Physical Education | 0 | 2 | 0 |
| | | | | | | | | | 17 |

Junior Year

| | Hours/Week | | |
| CM 118 | Chemical Equilibria | 2-3/10 | 5 | 4 |
| CM 162 | Physical Chemistry II | 3 | 0 | 3 |
| CM 504 | Chemical Laboratory Safety | 1 | 0 | 1 |
| | Hum./Soc. Sci. electives | 3 | 0 | 3 |
| | Elective | 3 | 0 | 3 |
| | | | | | | | | | 17 |

Senior Year

| | Hours/Week | | |
| CM 109 | Inorganic Chemistry Lab | 0 | 3 | 1 |
| CM 175 | Adv. Physical Chemistry | 4 | 0 | 4 |
| CM 390 | Bachelor's Thesis | 4 | 0 | 4 |
| | Hum./Soc. Sci. elective | 3 | 0 | 3 |
| | Elective | 3 | 0 | 3 |
| | | | | | | | | | 15 |

Total credits required for graduation: 128

58
**BIOCHEMISTRY OPTION**

Freshman and sophomore courses as above.

### Junior Year

<table>
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<th>Hours/Week</th>
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<tbody>
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<td>LS 105</td>
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<td>LS 115</td>
<td>General Biology Lab I</td>
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<td>CM 118</td>
<td>Chemical Equilibria</td>
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<tr>
<td>CM 182</td>
<td>Physical Chemistry II</td>
</tr>
<tr>
<td>CM 201</td>
<td>Biochemistry I</td>
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<td>CM 504</td>
<td>Chemical Laboratory Safety</td>
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<th>Second Semester</th>
<th>Hours/Week</th>
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<td>No.</td>
<td>Subject</td>
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<td>LS 106</td>
<td>Biology II</td>
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<td>LS 116</td>
<td>General Biology Lab II</td>
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<td>CM 177</td>
<td>Physical Chemistry Lab</td>
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<tr>
<td>CM 202</td>
<td>Biochemistry II</td>
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<tr>
<td>CM 204</td>
<td>Biochemistry Lab</td>
</tr>
<tr>
<td>CM 501</td>
<td>Chemical Literature</td>
</tr>
<tr>
<td>CM 108</td>
<td>Inorganic Chemistry</td>
</tr>
</tbody>
</table>

### Senior Year

| CM 109 | Inorganic Chemistry Lab |
| 0 | 3 | 1 |
| CM 390 | Bachelor’s Thesis |
| 391 | Electives | 3 |

| CM 119 | Analytical Chemistry |
| 3 | 0 | 3 |
| CM 120 | Analytical Chemistry Lab |
| 0 | 6 | 2 |
| CM 392 | Thesis |
| 394 | Electives | 3 |

**Total credits required for graduation: 128**

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

In humanities and social sciences, students 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 noncredit writing course before taking HU 101 (or HU 103).

Students are strongly urged to select areas 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 these concentrations in consultation with departmental advisers. Modern languages are recommended as suitable concentrations, but students without prior knowledge of languages must plan to devote at least 12 credit hours to each one.

For remaining humanities/social sciences requirements, students should select course in areas other than that of their concentrations. Additional courses in humanities and social sciences may be taken as free electives.

Students are strongly encouraged to take technical writing courses.

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

Students with special interests 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. Requirement for advanced chemistry courses are waived for students taking the biochemistry thesis option.

All laboratory courses in chemistry require a breakage deposit.

The department does not usually grant transfer credits to students who, while registered at Polytechnic, take chemistry courses at other schools.
Engineering Chemistry is a degree program in chemistry with a concentration in engineering principles and techniques associated with chemical processes. This degree allows students to enter industrial employment with advantages over a pure science degree and at the same time allows pursuit of M.S. or Ph.D. degrees in chemistry or chemical engineering.

**Curriculum for the Degree of Bachelor of Science in Engineering Chemistry**

Students should consult with advisers. The corresponding courses are strongly recommended. The following list can be used in consultation with advisers.

**Chemistry Curriculum Options**

**Freshman Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
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<tr>
<td>CM 101 General Chemistry I</td>
<td>2 1/2 0 2 1/2</td>
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<tr>
<td>CM 111 General Chemistry Lab I</td>
<td>6 0 6</td>
</tr>
<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3 0 3</td>
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<tr>
<td>PE 101 Physical Education</td>
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<tr>
<td>CS 100 Introduction to Computer Programming</td>
<td>2 0 2</td>
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<tr>
<td><strong>Total</strong></td>
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**Second Semester**

<table>
<thead>
<tr>
<th>No. Subject</th>
<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td>CM 102 General Chemistry II</td>
<td>2 1/2 0 2 1/2</td>
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<tr>
<td>CM 112 General Chemistry Lab II</td>
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<tr>
<td>MA 102 Calculus II</td>
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<td><strong>Total</strong></td>
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**Sophomore Year**

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<tr>
<td>CM 123 Chemical Process Analysis I</td>
<td>2 0 2</td>
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<tr>
<td>CM 122 Organic Chemistry I</td>
<td>3 0 3</td>
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<tr>
<td>CM 124 Organic Chemistry Lab I</td>
<td>3/10 5 2</td>
</tr>
<tr>
<td>MA 103 Calculus III</td>
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</tr>
<tr>
<td>PH 103 Introductory Physics III</td>
<td>2 1 3/2 3</td>
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<td>PE 103 Physical Education</td>
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<td><strong>Total</strong></td>
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**Junior Year**

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<th>Hours/Week</th>
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<tbody>
<tr>
<td>CH 251 Chemical Eng, Therm.</td>
<td>4 0 4</td>
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<tr>
<td>CH 220 Transfer Operations I</td>
<td>4 0 4</td>
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<tr>
<td>CM 118 Chemical Equilibria</td>
<td>2 3/10 5 4</td>
</tr>
<tr>
<td>CM 122 Physical Chemistry II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 104 Chemical Process Analysis I</td>
<td>6 0 6</td>
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<td>PE 104 Physical Education</td>
<td>0 2 0</td>
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<td><strong>Total</strong></td>
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**Senior Year**

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<th>Hours/Week</th>
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<tr>
<td>CM 175 Physical Chemistry III</td>
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<td>MA 105 Analytical Chemistry</td>
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<td>CM 125 Organic Chemistry Lab II</td>
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<td>CM 211 Transfer Operations II</td>
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<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 129 Analytical Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 129 Analytical Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 129 Analytical Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 129 Analytical Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 129 Analytical Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 271 Engineering Materials</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 120 Analytical Chemistry Lab</td>
<td>0 6 2</td>
</tr>
<tr>
<td>CM 241 Multistage Separation Processes</td>
<td>3 0 3</td>
</tr>
</tbody>
</table>
Honors Curricula in Chemistry for B.S. and Ph.D.Degrees

Honors Curricula are designed for the talented and motivated student with good scholastic preparation and a serious interest in chemistry. Students can complete B.S. and Ph.D. degrees in only six years. These accelerated curricula satisfy the normal requirements for both degrees.

While rewarding careers in chemistry can certainly begin with B.S. degrees, Ph.D. chemists have more opportunities, more responsibilities, higher salaries and greater potential for advancement in industry, government or academia. Many chemistry students begin college with the B.S. as their goal, only to realize in their junior year that they should aim for graduate school.

Graduate school in chemistry seems distant, forbidding and expensive to high school juniors and seniors, but need not be. This program enables students to complete requirements for Bachelor of Science degrees (certified by the American Chemical Society) after three years, at which time they also have begun graduate level courses. In the fourth year, students hold full graduate status, are paid graduate Teaching Assistant stipends. Support as Teaching or Research Assistants continue until the Ph.D. is completed.

Besides the equivalency credits required before matriculation, a B average must be maintained throughout the program, and a minimum B grade is required in chemistry courses during the first two years. Applications should be made to Polytechnic, and the student interested in this program should contact the chemistry department advisors. Formal application to the graduate program is made in the fall of the third year. The B.S. degree is awarded at the first regularly scheduled commencement after the third summer, and the Ph.D. degree is conferred after the doctoral dissertation is defended and deposited.

Equivalency work required prior to matriculation:

<table>
<thead>
<tr>
<th>Subject</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 101 General Chemistry Lecture I</td>
<td>2 5/6</td>
</tr>
<tr>
<td>CM 111 General Chemistry Laboratory I</td>
<td>1 1/6</td>
</tr>
<tr>
<td>CM 102 General Chemistry Lecture II</td>
<td>2 5/6</td>
</tr>
<tr>
<td>CM 112 General Chemistry Laboratory II</td>
<td>1 1/6</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3</td>
</tr>
<tr>
<td>MA 101 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>Humanities/Social Science**</td>
<td>6</td>
</tr>
<tr>
<td>(e.g. language, history. Two courses)</td>
<td></td>
</tr>
<tr>
<td>**</td>
<td>Total 19</td>
</tr>
</tbody>
</table>

*Equivalency certification may vary from department to department. Please check with individual departments or chemistry advisers for details.

**A second language in addition to English is strongly recommended, e.g., French, German or Russian; courses can be selected with the aid of advisers, or equivalency credits may be established. A technical writing course is also strongly recommended.

First Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>CM 122 Organic Chemistry Lectures</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CM 124 Organic Chemistry Laboratory</td>
<td>3/10</td>
</tr>
<tr>
<td></td>
<td>PH 102 Introductory Physics II</td>
<td>3 1/2</td>
</tr>
<tr>
<td></td>
<td>MA 102 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PE 101 Physical Education</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CM 504 Chemical Laboratory Safety</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Humanities/Social Science elective**</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17</td>
</tr>
<tr>
<td>First Summer Session</td>
<td>CM 161 Physical Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Humanities/Social Science elective**</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
</tr>
<tr>
<td>Second</td>
<td>CM 123 Organic Chemistry Lectures</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CM 125 Organic Chemistry Laboratory</td>
<td>3/10</td>
</tr>
<tr>
<td></td>
<td>PH 103 Introductory Physics III</td>
<td>2 1/2</td>
</tr>
<tr>
<td></td>
<td>MA 103 Calculus III</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CS 100 Introductory Computing</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>PE 102 Physical Education</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Humanities/Social Science elective**</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>16</td>
</tr>
<tr>
<td>Second Summer Session</td>
<td>CM 162 Physical Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Humanities/Social Science elective†</td>
<td>3</td>
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<tr>
<td></td>
<td>Total</td>
<td>6</td>
</tr>
<tr>
<td>Total credits: 45</td>
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</tr>
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</table>

Second Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 118 Chemical Equilibria</td>
<td>2-3/10</td>
<td></td>
</tr>
<tr>
<td>CM 175 Advanced Physical Chemistry</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PE 103 Physical Education</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Technical elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Electives (two)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17</td>
</tr>
<tr>
<td>First Summer Session</td>
<td>Humanities/Social Science electives (two)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
</tr>
<tr>
<td>Second</td>
<td>CM 108 Inorganic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CM 119 Analytical Chemistry Lecture</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CM 120 Analytical Chemistry Laboratory</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CM 177 Physical Chemistry Laboratory</td>
<td>3/10</td>
</tr>
<tr>
<td></td>
<td>CM 501 Chemical Literature</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>CM 871 Guided Studies</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>PE 104 Physical Education</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17</td>
</tr>
<tr>
<td>Second Summer Session</td>
<td>Humanities/Social Science electives (two)</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>6</td>
</tr>
<tr>
<td>Total credits: 46</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Third Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 109</td>
<td>Inorganic Chemistry Laboratory</td>
<td>0 3 1</td>
</tr>
<tr>
<td>CM 703</td>
<td>Advanced Physical Chemistry I</td>
<td>3 0 4½</td>
</tr>
<tr>
<td>CM 903</td>
<td>Advanced Organic Chemistry I</td>
<td>3 0 4½</td>
</tr>
<tr>
<td>CM 971</td>
<td>Colloquium in Chemistry</td>
<td>0 0 0</td>
</tr>
<tr>
<td>CM 973</td>
<td>Seminars in Chemistry</td>
<td>1 0 1½</td>
</tr>
<tr>
<td>CM 907</td>
<td>Spectroscopy of Organic Molecules</td>
<td>3 0 4½</td>
</tr>
<tr>
<td>CM 872</td>
<td>Guided Studies</td>
<td>TBA 0 4½</td>
</tr>
</tbody>
</table>

During this semester, the student shall make formal application to the Graduate Program in Chemistry.

Summer Session (either first, second or both)

Electives (two)  
Total credits: 40

At this point, the student has completed all requirements for the B.S. degree in chemistry, and amassed 21 credits toward the Ph.D. B.S. degrees are conferred at the next scheduled commencement. In the fourth year, students are considered full-fledged graduate students, and are supported by teaching or research assistantships.

### Fourth Year

#### First Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 601</td>
<td>Advanced Inorganic Chemistry</td>
<td>0 4½</td>
</tr>
<tr>
<td>CM 971</td>
<td>Colloquium in Chemistry</td>
<td>0 0 0</td>
</tr>
<tr>
<td>CM 975</td>
<td>Seminar in Chemistry</td>
<td>1 0 1½</td>
</tr>
<tr>
<td>CM 991</td>
<td>Special Experimental Techniques</td>
<td>TBA TBA 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 992</td>
<td>Special Experimental Techniques</td>
<td>TBA TBA 3</td>
</tr>
</tbody>
</table>

Advanced Chemistry Course  
Total credits: 12

#### Second Semester

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 972</td>
<td>Colloquium in Chemistry</td>
<td>0 0 0</td>
</tr>
<tr>
<td>CM 976</td>
<td>Seminar in Chemistry</td>
<td>1 0 1½</td>
</tr>
<tr>
<td>CM 992</td>
<td>Special Experimental Techniques</td>
<td>TBA TBA 3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 998</td>
<td>Research in Chemistry</td>
<td>TBA TBA 7</td>
</tr>
</tbody>
</table>

Advanced Chemistry Courses (two)  
Total credits: 6

#### Fifth Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 971</td>
<td>Colloquium in Chemistry</td>
<td>0</td>
</tr>
<tr>
<td>CM 999</td>
<td>Research in Chemistry</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 999</td>
<td>Research in Chemistry</td>
<td>3</td>
</tr>
</tbody>
</table>

Advanced Chemistry Course  
Total credits: 18

#### Sixth Year

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 971</td>
<td>Colloquium in Chemistry</td>
<td>0</td>
</tr>
<tr>
<td>CM 999</td>
<td>Research in Chemistry</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM 999</td>
<td>Research in Chemistry</td>
<td>18</td>
</tr>
</tbody>
</table>

Year's Total credits: 36

| Year's Total credits: 36 |
Advanced chemistry courses are selected from the following list, which appears in the catalog under appropriate interest areas.

**INORGANIC CHEMISTRY**
CM 614-619 Special Topics in Inorganic Chemistry

**PHYSICAL CHEMISTRY**
CM 712 Research Instrumentation
CM 715-717 Advanced Topics in Physical Chemistry: Kinetics of Chemical Reactions, Valence and Molecular Structures, Electrochemistry
CM 721 Quantum Mechanics for Chemists
CM 722 Statistical Mechanics for Chemists
CM 730-731 Group Theory and Applications I & II
CM 750 Special Topics in Physical Chemistry
CM 760 Minicomputer Instrumentation for Scientific Research

**POLYMER CHEMISTRY**
CM 771 Introductory Polymer Chemistry
CM 772 Synthesis of High Polymers
CM 781 Solution Properties of High Polymers
CM 782 Macromolecules in the Solid State
CM 783 Laboratory Methods in Polymer Chemistry
CM 785 Special Topics in Polymer Chemistry
CM 790 Biopolymers

**ORGANIC CHEMISTRY**
CM 915 Topics in Physical Organic Chemistry
CM 920 Current Aspects of Organic Synthesis
CM 921-933 Advanced Topics in Organic Chemistry
CM 940 Special Topics in Organic Chemistry

**BIOCHEMISTRY**
CM 941-942 Biochemistry I & II
CM 943-946 Advanced Topics in Biochemistry
CM 947 Biochemical Techniques

With adviser's approval, courses in other departments may be taken instead of the advanced chemistry courses, such as courses in Physics, Metallurgy, Computer Sciences, Chemical Engineering and Bioengineering.

There are four major areas in chemistry for the Ph.D. Degree, and there are individual requirements in each area:

**INORGANIC CHEMISTRY**
At least six units of advanced topics in Inorganic Chemistry, and either CM 802 or CM 905

**ORGANIC CHEMISTRY**
CM 905 and CM 920.
committee, including the research adviser (major adviser), a minor adviser, and at least two additional faculty members, who monitor the progress of the student through the rest of the program. Approximately six months after the Written Preliminary Examination, an Oral Preliminary Examination is scheduled, where students will present plans, and possibly the results from specific areas of thesis research, for evaluation by the committee. When all thesis research is completed, the student schedules an Oral Defense of the thesis; final judgement is made by the dissertation committee on awarding a Ph.D. degree.

Academic policy for the graduate program in chemistry requires that a B average be maintained. Similarly a B average is required for a student to remain in the Honors Program. B minimum grades in chemistry courses must be maintained during the first two years of study.

GRADUATE STUDIES

Admission to graduate studies 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 students to have had differential equations, atomic and nuclear physics, and two years of German, Russian or French. Chemistry graduate students cannot take CM 500 level courses for graduate credit, except for MS degree candidates in Industrial Chemistry.

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 a 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>4.5</td>
</tr>
<tr>
<td>CM 703</td>
<td>Chemical Physics I</td>
<td>4.5</td>
</tr>
<tr>
<td>or</td>
<td>CM 704</td>
<td>Chemical Physics II</td>
</tr>
<tr>
<td>CM 802</td>
<td>Applied Spectroscopy</td>
<td>4.5</td>
</tr>
<tr>
<td>or</td>
<td>CM 907</td>
<td>Organic Spectroscopy</td>
</tr>
<tr>
<td>CM 903</td>
<td>Advanced Organic Chemistry I</td>
<td>4.5</td>
</tr>
<tr>
<td>or</td>
<td>CM 904</td>
<td>Advanced Organic Chemistry II</td>
</tr>
</tbody>
</table>

Students may elect research and a thesis (12 units). The 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 these are required to take 3-6 units of guided studies. (CM 871-872) with the submission of a written report.

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

Students must be in continuous attendance at departmental colloquia.

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

Industrial Chemistry

The Department of Chemistry offers a master of science degree 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 950-951</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 Changes, Research and Developments</td>
<td>3</td>
</tr>
<tr>
<td>either</td>
<td>CM 760</td>
<td>Minicomputer Instrumentation for Scientific Research</td>
</tr>
<tr>
<td>or</td>
<td>MA 531</td>
<td>Applied Mathematics for Engineers</td>
</tr>
<tr>
<td>CM 955</td>
<td>Project in Industrial Chemistry</td>
<td>0</td>
</tr>
<tr>
<td>CM 504</td>
<td>Chemical Laboratory Safety</td>
<td>18-21</td>
</tr>
</tbody>
</table>

At least 12-15 units must be taken from graduate courses in chemistry numbered above 600. Remaining units are chosen from the following list and from other graduate courses in chemistry:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS 672</td>
<td>Technological Forecasting</td>
<td>3</td>
</tr>
<tr>
<td>CH 915-916</td>
<td>Introduction to Polymeric Materials I, II</td>
<td>3</td>
</tr>
<tr>
<td>CH 921</td>
<td>Polymer Processing</td>
<td>3</td>
</tr>
<tr>
<td>HU 605</td>
<td>Technical Writing</td>
<td>3</td>
</tr>
<tr>
<td>CM 502</td>
<td>Environmental Chemistry</td>
<td>3</td>
</tr>
</tbody>
</table>

REQUIREMENTS FOR THE DOCTOR'S DEGREE

Admission to doctoral programs 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.

Currently the Chemistry Department offers the Ph.D. degree with majors in inorganic, organic, physical or polymer chemistry. Minors are also required and may be in any of these areas other than the major and, additionally, in biochemistry or other departments or areas such as polymer science and engineering. The program includes the following courses, for which students must maintain at least a B average.
1. Required Courses

In the doctoral curriculum, required courses are listed below.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</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</td>
<td>4½</td>
</tr>
<tr>
<td>or CM 704</td>
<td>Chemical Physics II</td>
<td>4½</td>
</tr>
<tr>
<td>CM 802</td>
<td>Applied Spectroscopy</td>
<td>4½</td>
</tr>
<tr>
<td>CM 907</td>
<td>Organic Spectroscopy</td>
<td>4½</td>
</tr>
<tr>
<td>CM 903</td>
<td>Organic Chemistry I</td>
<td>4½</td>
</tr>
<tr>
<td>or CM 904</td>
<td>Organic Chemistry II</td>
<td>4½</td>
</tr>
</tbody>
</table>

These courses are offered in two consecutive terms so that full-time students entering in the fall term can complete the sequence in two terms. In addition to the 18 credits of required courses listed, Ph.D. students must take a one-credit course in laboratory safety, CM 504, and fulfill the seminar and other requirements described in the catalog. Course requirements are explicitly defined below.

2. Required Courses for Chemistry Majors

Listed below are required courses for the four major areas in chemistry, i.e., inorganic, organic, physical and polymer.

**Inorganic Chemistry:** CM 601, CM 903 or CM 904, CM 802 or CM 907, CM 703 and at least six units of advanced topics in inorganic chemistry (CM 614-619).

**Organic Chemistry:** CM 601, CM 703 or 704, CM 903, CM 904, CM 907 and CM 920.

**Physical Chemistry:** CM 703, CM 704, CM 802 or 907, CM 903 or 904, PH 313-314, CM 721, CM 722 and CM 995.

**Polymer Chemistry:** CM 601, CM 703 or 704, CM 802 or 907, CM 903 or 904, CM 771, CM 772, CM 781, CM 782, and CM 783.

3. Minor Requirements

The Chemistry Department offers a minor concentration in biochemistry, inorganic, organic, physical and polymer chemistry. Students may elect a minor in areas of concentration offered by other departments. In all cases a faculty adviser from the minor areas will be a member of the Guidance Committee. The student shall select courses to fulfill minors in consultation with the minor adviser.

4. Participation in seminar for four semesters, twice as a lecturer.


6. Students whose native language is not English must demonstrate competence in English.

7. By the end of the second year, students are required to pass preliminary examinations, administered by the Guidance Committee, which consist of written and oral portions.

8. Students must be in continuous attendance at departmental colloquia for the duration of research.

9. The final oral examination will take place after members of the Guidance Committee have read the dissertation in typed, unbound form.

All students in the doctoral program are granted master of science degrees upon satisfactory completion with a B average of course requirements and 12 units of research toward doctoral dissertations, as certified by the chairman of the Guidance Committee. On application to the Office of Research and Graduate Studies and after completion of preliminary examinations, the student is certified as having earned a 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 101 General Chemistry I**

2½:10:2½ Chemical conservation laws; states of matter; acid-base and oxidation-reduction theories; introduction to chemical thermodynamics and chemical equilibria. Elective for Ph.D. students.

**CM 102 General Chemistry II**

2½:10:2½ 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 structures of elements as basis for periodic classification. Descriptive chemistry of elements and their compounds. Theories 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 151.

**CM 111 General Chemistry Laboratory I**

0:1½:½ Introduction to chemical laboratory procedures. Laboratory associated with lecture courses CM 101. Lab fee required.

**CM 112 General Chemistry Laboratory II**

0:1½:½ Laboratory experiments in qualitative analyses are taken in conjunction with CM 102. Lab fee required. Prerequisites: CM 101, CM 111.

**CM 118 Chemical Equilibria**

2½:5:4 Equilibria in homogeneous and heterogeneous chemical processes. Applications of equilibrium concepts and data to analytical and physical chemistry. Theory of titrations and other analytical processes. Thermodynamic and chemical interpretations of equilibrium data. Separation; techniques. Lab fee required. Prerequisites: CM 161-162.

**CM 119 Instrumental Methods in Analytical Chemistry**

3:0:3 Theories and applications 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 physical-chemical interpretation of data obtained. Lab fee required. Prerequisites: CM 118 and CM 151-152. 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, and stereochemistry. Prerequisites: CM 102 and CM 112.

CM 124 Organic Chemistry Laboratory 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 ½:5:23
Laboratory methods for preparation, purification, characterization and identification of organic compounds by chemical and physical means. Introduction to 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 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

CM 201 Biochemistry I 3:0:3
Surveys of modern biochemistry with emphasis on current areas of research. Structure-function relationships in proteins and nucleic acids. Enzymes and their mechanisms of action. Bioenergetic principles and energy production. Biochemical theories and techniques. Prerequisites: CM 123, CM 125 and CM 151, or instructor's permission.

CM 202 Biochemistry II 3:0:3
Continuation of Biochemistry I. Important principles of intermediary metabolism, energetics, membrane structure and 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 each 2 credits
Original investigations by student under guidance of staff members. Careful literature search required before inception of laboratory work; continued reference to chemical literature expected, and active participation in conference and seminars scheduled as work progresses. Students required to give oral resumes 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. Reregistration beyond CM 394, 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.

SPECIAL LISTINGS:

Undergraduate and Graduate

CM 501† Chemical Literature 1:0:1
Programs of lectures, exercises and discussion designed to familiarize students with the chemical literature. Undergraduate students may emphasize topics related to the 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 of the environment. Chemical properties of pollutants in air, water, soil. Effects of chemical pollutants on health. Prerequisites: CM 122, CM 124 and CM 161 or CM 164 or instructor's permission. This course does not fulfill requirements for the regular M.S. or Ph.D. degrees in chemistry. M.S. candidates in industrial chemistry may collect this course to meet degree requirements.

CM 504† Chemical Laboratory Safety 1:0:1
Discussions 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.

CM 515 Polymer Organic Chemistry 2½:0:3
Review of basic organic chemistry. Synthesis, characterization and applications to polymer materials. May not be taken for credit by undergraduates to substitute for CM 122-123. May not be taken for graduate credit by graduate students in Chemistry or Polymer Science and Engineering. Prerequisite: CM 101, 102 or consent of instructor.

GRADUATE COURSES

INORGANIC CHEMISTRY

CM 601† Inorganic Chemistry 3½:0:4½
Theories of bonding of inorganic compounds. Introduction to group theory as applied to molecular orbital and ligand field theories. 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 the solid state, chemistry of coordination compounds, mechanisms of inorganic reactions, chemistry of non-metals, inorganic polymers, chemistry of representative elements, bonding theories. Prerequisite: CM 601 and adviser's approval.
CM 703  Chemical Physics I 3 1/4:0:4 1/2

CM 704  Chemical Physics II 3 1/4:0:4 1/2
Chemical kinetics and thermodynamics. Fundamental ideas of statistical mechanics. Development of relationships of various bulk properties of matter to molecular structures and interactions. Applications to solutions, polymers. Prerequisites: Undergraduate physical chemistry and physics.

CM 712  Research Instrumentation* 2 1/2:5:6
Laboratory course in electronics for students planning to use electronic instrumentation in research. Malmsstadt/Enke Instrumentation Laboratory used. Power supplies; vacuum tube and solid state amplifiers; oscillators; servo systems; operational amplifiers; digital instrumentation. Prerequisite: advisor's approval. Also listed under CH 841, BE 622 and SA 605.

CM 717  Advanced Topics in Physical Chemistry 2 1/2:0:3
Selections from the following topics may be offered at regular intervals: Kinetics of Chemical Reaction, Valence and Molecular Structure, Electrochemistry.

CM 721  Quantum Mechanics for Chemists* 3 1/4:0:4 1/2
Principles of quantum mechanics quantitatively developed. Comparison of various approaches. Most important approximation methods useful for applications of theory to many problems in chemistry and physics. Detailed discussions of several applications to some basic problems. Required of all Ph. D. candidates with major in physical chemistry. Prerequisite: CM 704, PH 501 and H 602.

CM 722  Statistical Mechanics for Chemists* 3 1/4:0:4 1/2
Classical and quantum statistical mechanics systematically developed and applied to thermodynamics of chemical 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 730-371  Group Theory and its Applications I, II  each 2 1/2:0:3
Group theory and its application 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 theories; energy band theories 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* 2 1/2:0:3
Advanced or specialized topics in physical chemistry presented at irregular intervals.

CM 760†  Minicomputer Instrumentation for Scientific Research 1 1/4:2:3
Fundamentals of digital electronics and minicomputers; computer-automated laboratory instrumentation; programming and interfacing required for data acquisition and control in scientific research. Experiment with minicomputers and laboratory apparatus interfaced directly to minicomputers. Lab fee required. Prerequisite: Instructor's permission. Also listed under PH 612 and BE 623.

CM 771  Introductory Polymer Chemistry 2 1/2:0:3
Syntheses 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 162.

CM 772  Synthesis of High Polymers 2 1/2:0:3
Organic aspects. Chemistry of monomer and polymer formations, Modern mechanistic analyses of reactions. Stereochemistry of polymer structures and forces of stereoregulation. Condensation; free radical (bulk, suspension, emulsion, solution); ionic, ring-opening and nonclassical polymerization reactions.

CM 781  Solution Properties of High Polymers 2 1/2:0:3
Application of viscometry, light scattering, equilibrium ultracentrifugation, electrophoresis, 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 Solid States* 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 0:4:3
Experiments on free radical condensation; ionic and copolymerization; absorption; 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.

CM 790  Biopolymers 2 1/2:0:3
Structure and properties of important biological macromolecules including proteins, nucleic acids and polysaccharides, membranes and macromolecular complexes; applications of x-ray diffraction, NMR, vibrational and CD spectroscopy to the analysis of structure. Biopolymers may be used to satisfy major field requirements in polymer or minor field requirements in biochemistry. Offered in alternate years. Pre-Corequisite: CM 941 or consent of instructor.

ANALYTICAL CHEMISTRY

CM 802  Applied Spectroscopy 3 1/2:4 1/2
Solving chemical problems using spectroscopic methods. Vibrational, electronic, nuclear magnetic resonance spectroscopy and mass spectrometry. Discussion of physical principles, instrumentation, interpretation of spectra, applications to molecular and physical problems. Prerequisite: CM 703
ORGANIC CHEMISTRY

CM 903 Organic Chemistry I 3 1/2:0:4 1/2
Molecular structure and bonding. Stereochemical 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 1/2:0:4 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. Suggested prerequisite: CM 903 or consent of instructor.

CM 907 Organic Spectroscopy 3 1/2:0:4 1/2
Structure elucidation by joint applications of spectroscopic techniques such as proton and carbon-13 magnetic resonance, infrared and mass spectroscopy, and other methods.

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 or CM 904.

CM 920 Current Aspects of Organic Synthesis* 2 1/2:0:3
Approaches to syntheses of organic molecules. Stereoselective and stereospecific reactions. Examples drawn from naturally occurring and theoretically interesting molecules. Prerequisite: CM 903 or CM 904.

CM 921-933 Advanced Topics in Organic Chemistry* 2 1/2:0:3
Selections from the following topics will be offered at irregular intervals: organometallic chemistry, photochemistry, heterocyclic chemistry, and natural products. Prerequisite: CM 903 or CM 904.

CM 940 Special Topics in Organic Chemistry* 2 1/2:0:3
Topics selected from current research or literature, and approaches to problem solving. Co/Prerequisite: CM 903 or CM 904.

INDUSTRIAL CHEMISTRY

CM 950-951 Industrial and Engineering Chemistry I, II each 2 1/2:0:3
Discussions of the chemical process industries, emphasizing basic chemical and physical principles, as well as economic feasibility of individual processes, to provide chemical engineering backgrounds 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 analyses and recycling, stagewise and continuous contact equipment and flow sheet analyses. 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 Projects in Industrial Chemistry as arranged
Directed studies or supervised reading and/or experimental work in advanced areas of chemical and chemical technologies. Conferences scheduled. Candidates for M.S. degree program required to submit four unbound copies of typewritten project reports and present 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 971-972 Directed Studies in Chemistry as arranged
Directed studies 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 1 1/2 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 991-992 Special Techniques in Experimental Chemistry I, II each 0:6:3
Specialized techniques and processes of modern experimental chemistry. Depending upon requirements of thesis students and recommendations of advisors, advanced laboratory skills in X-ray diffractions, solid state synthesis, measurements of magnetic moments and susceptibilities, spectroscopic techniques, chromatographic techniques, thermal analyses, relaxation kinetics, electrochemistry, etc. Emphasis on intensive training in students' research activities. May be taken for a maximum of two semesters. Prerequisite: Concurrent thesis registration and permission of advisor and course director.

CM 995-996 Seminar in Chemical Physics* each 1 1/2 units
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 serves as basis for master's degrees. To be taken by Ph.D. candidates before completion of Ph.D. preliminary examinations in chemistry. Minimum research registration requirements for the master's degree: 12 units. Registration for research required each semester consecutively until students have completed adequate research projects and acceptable thesis and passed required oral examinations. Research credits registered for each semester reflect realistically time devoted to research. A maximum of 8 units may be counted towards a Ph.D. in chemistry. Research charge: Prerequisites: for M.S. candidates, degree status and consent of graduate advisor and thesis director and CM 5041.
CM 999 Research in Chemistry 3 units
Original experimental or theoretical research (undertaken under
guidance of a chemistry faculty member), which may serve as ba-
sis for degree of doctor of philosophy. Chemical physics majors
with thesis advisers in Department of Physics should register for PH
791-796 and PH 981-993. Minimum research registration require-
ments for 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 un-
til students have completed adequate research projects and ac-
ceptable theses and passed required oral examinations. Number of
research credits registered for each semester must reflect realisti-
cally time devoted to research. Research fees required. Prerequi-
sites: completion of Ph.D. preliminary examination in chemistry and
consent of thesis director and CM 504†.

LIFE SCIENCES COURSES

In recent years, Polytechnic has developed life sciences
courses which complement those in its teaching and
research programs in engineering and physical sciences.
Undergraduate students with specific interests in the areas
of biology, biochemistry, environmental sciences,
bioengineering, premedicine and laboratory techniques
may elect life science courses to fulfill specific B.S.
program requirements or to serve as technical or free
electives.

Biology is concerned with the study of life in all
manifestations—from the simple to the complex, from the
invisible to the macroscopic, from the virus to the human.
To move beyond definitions of life to understanding life's
fundamental nature, characteristics of living systems must
be examined, including growth, heredity and reproduction,
metabolism, energy production and utilization, responsive-
ness, and locomotion. Structures and function of living
matter at the molecular, cellular and organismal levels
must be probed. Biology, chemistry and physics contrib-
te to understanding of living systems.

UNDERGRADUATE COURSES

LS 105-106 General Biology I, II each 3:0:3
Fundamentals of biology. Physical, chemical, biochemical bases
of life on various organizational levels. Cellular morphology, comple-
mentarity of form and function. Reproduction, development, gener-
ics. Homeostasis, regulation, integration, coordination. Prerequisite:
high school chemistry. LS 105 prerequisite: LS 105 or instructor's consent.

LS 115-116 General Biology Laboratory I, II 1:2:2
Prerequisites: General Biology I, II. In conjunction with laboratory,
theoretical lectures on the levels of organization of living things;
unifying and diverse mechanisms of living things; genetics, development, homeostasis, integration and coordination;
adaptation to the environment, ecology and the biological ba-
ses of behavior. Lab fee required. Prerequisites: LS 105. LS 115 Co/
Prerequisite: LS 105. LS 116 Co/Prerequisite: LS 105.

LS 140 Environmental Biology* 2:2:0:3
Prerequisite: MA 104 or instructor's consent.
Studies of interrelationships of organisms and their environments.
Structures and dynamics within the ecosystem including bioge-
ophysical cycles, energy, populations and food supply. Effects of
pollution and technology as they influence alternatives. Econom­
ic, legal and policy decisions in environmental management are
considered. Knowledge of FORTRAN or similar languages desire-
able. Lab fee required. Co/Prerequisite: MA 104 or instructor's consent.

LS 103-200 Topics in Biology Credit as arranged
From time to time courses may be offered in the following areas:
Developmental Biology, Fundamentals of Genetics, Microbiology,
Physiology, Cell Physiology, Cell Biology, Techniques and Instrumentation. Histological Techniques, and others.

LS 305-307 Senior Projects in Life Sciences each 2 credits
Investigations of problems in biology under supervision of faculty
members. Library research, experimental studies, written reports
required. Lab fee required. Prerequisite: senior status or adviser's consent.

LS 308 Life Science Internship 2 credits
Supervised projects carried out in hospital, community or industrial
settings. Evaluation based on written and oral reports presented
to faculty and outside project co-sponsors. Faculty conferences
and visits required. Open to senior students on approval of depart­
mental adviser. Preplanned experiences require students with
significant exposure to relationships between theoretical informa-
tion and practical application. Prerequisite: senior status or adviser's consent.

LS 310 Seminar in Biology* 1 credit
Selected topics of current interest presented by participating stu-
dents, staff and outside lecturers. Prerequisites: LS 105 and LS
106.

GRADUATE COURSES

LS 561-702 Advanced Topics in Biology Credit as arranged
From time to time, graduate level courses may be offered in Elec-
tron Microscopy, Neurophysiology, Topics in Neurosciences, and
Cytology.

LS 900 Selected Topics in Biology* 2:2:0:3
Prerequisite: senior status or adviser's consent.
Presentation of significant topics in biology or related interdiscipli-
nary areas. Topics may vary from year to year.

FACULTY

William H. Starnes, Professor and Head, Department of
Chemistry
B.S., Virginia Polytechnic Institute, Ph.D., Georgia Institute
of Technology
Polymer Degradation, stabilization, and Microstructure; mechanisms of organic reactions.

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

Mary K. Cowman, Associate Professor of Biochemistry
B.S., M.S., Ohio University, Ph.D., Case Western Reserve
Solution conformation and interactions of complex carbo-
hydrate polymers; circular dichroism and nuclear magnetic
resonance spectroscopy; biochemistry of extracellular
matrix components.
**CHEMISTRY**

**Frederick Eirich,** Distinguished Professor of Polymer Chemistry  
Ph.D., University of Vienna  
Mechanical behavior of polymers; rheology; colloid chemistry; chemical evolution; biopolymers

**Bruce A. Garetz,** Associate Professor of Physical Chemistry  
A.B., Harvard College; Ph.D., Massachusetts Institute of Technology  
Laser spectroscopy; nonlinear optics and multiphoton processes; molecular dynamics

**Mark M. Green,** Associate Professor of Organic Chemistry  
B.S., CCNY; Ph.D., Princeton University  
Stereochemistry of reactive intermediates; macromolecular stereochemistry; isolation of bio-active plant substances

**Sybilla Kennedy,** Academic Associate and Director of Laboratories (Farmingdale)  
B.A., Smith College; M.A., SUNY (Stony Brook)  
Applied polymer science; fiber science; thermal dehydra­tion and flammability of polymers; composites; and poly­mers from electronics applications

**Ernest M. Loeb,** 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.S.Sc., M.S.Sc., University of Toronto; Ph.D., Polytechnic Institute of Brooklyn  
Polymer reactions; hindered rotation in polymer systems, properties of polymer gels, and 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

**Yoshiyuki Okamoto,** Professor of Organic and Polymer Chemistry  
B.S., Osaka University of Science and Engineering (Japan); Ph.D., Purdue University  
Organic and polymer synthesis, characterizations and applications

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

**Norman C. Peterson,** Professor of Physical Chemistry  
B.S., Massachusetts Institute of Technology; Ph.D., Iowa State University  
Molecular beam scattering; laser chemistry; reaction kinetics

**Sergio Petrucci,** Professor of Physical Chemistry  
Ph.D., University of Rome  
Relaxation kinetics; ligand substitution in non-aqueous media; microwave and diffusional rotational relaxation

**Arnost Reiser,** Research Professor of Chemistry  
Dr. Ing. (Prague); D.Sc. (London)  
Polymer photochemistry; photoresists; image science

**Matthew Schlecht,** Assistant Professor of Organic Chemistry  
B.S., University of Wisconsin; M.A., Ph.D., Columbia University  
Synthetic methods; total synthesis of natural products; organometallic reactions; medicinal chemistry.

**Donald M. Schielch,** Associate Professor of Inorganic Chemistry  
B.S., SUNY (Fredonia); Ph.D., Brown University  
Photoelectrochemistry, intercalation and materials studies

**Giuliana Tesoro,** Research Professor of Polymer Chemistry  
Ph.D., Yale University  
Polymer synthesis polymer stabilizers; polymer drugs

**Otto Vogl,** Herman F. Mark Professor of Polymer Chemistry  
Ph.D., University of Vienna  
Polymer synthesis polymer stabilizers; polymer drugs

**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; CP-MAS NMR

**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 build 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 control 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 study 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, languages 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 application—such as highways, environmental engineering and detailed design of structure—are studied. The emphasis is on preparing students broadly in all major areas of civil and environmental engineering so that graduates can be immediately employed in the profession.

Technical Electives

To allow students to broaden their technical knowledge, the curriculum provides 12 elective credits of appropriate coursework. Approved technical electives are indicated below; senior courses in other departments as well as selected graduate courses (CE 590, CE 601, CE 780, CE 781, CE 854) may be chosen but they require the approval of a departmental advisor. A minimum of 6 technical elective credits, carrying civil engineering designation must be completed at Polytechnic; only one course may be in mathematics.

<table>
<thead>
<tr>
<th>No.</th>
<th>Technical Electives</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CE 272</td>
<td>Construction Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 336</td>
<td>Timber and Masonry Structures</td>
<td>3</td>
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<tr>
<td>CE 345</td>
<td>Hydraulic Engineering</td>
<td>3</td>
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<tr>
<td>AM 331</td>
<td>Computational Methods in Computer Aided Design</td>
<td>3</td>
</tr>
<tr>
<td>IE 300</td>
<td>Engineering Economy</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>
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<tr>
<td>MA 223</td>
<td>Introduction to Probability</td>
<td>3</td>
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<tr>
<td>MA 260</td>
<td>Vector Analysis and Partial Differential Equations</td>
<td>4</td>
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<tr>
<td>TR 360</td>
<td>Traffic Planning and Operations</td>
<td>3</td>
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<tr>
<td>TR 361</td>
<td>Transportation Demand Models</td>
<td>3</td>
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<tr>
<td>TR 362</td>
<td>Public Transportation</td>
<td>3</td>
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</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 two-credit courses MS 301, 303, 401 and 403 for six credits of technical electives.

Humanities and Social Science Requirements

Elective courses are chosen in consultation with a civil engineering undergraduate advisor according to the following university and departmental guidelines.

In humanities and social sciences, students must take HU 101, HU 110 and either HU 200 and SS 104 or IS 140 and IS 141 (total 12 credits). Students 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 noncredit course before taking HU 101 (or HU 103). All students must elect 12
additional credits in humanities and social sciences to bring to 24, the total of such credits.

At least 18 of the credits students select in the humanities and social sciences must meet the requirements of the Accreditation Board for Engineering and Technology (ABET). These credits may not include skills-oriented courses such as technical writing, public speaking, or English as a second language. Courses in literature, foreign languages, history, economics, and others are acceptable. Students should consult their advisers to ensure that these criteria are met.

Students should select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religions in the Department of Humanities and Communication, or economics, history, anthropology, or psychology in the Department of Social Sciences) and elect a number of courses in this concentration, in consultation with their adviser. A modern language may be chosen as a suitable concentration but students without prior knowledge of the language must plan to devote at least 12 credit hours to it.

Management courses and ROTC courses may not be used.

TRANSFER STUDENTS (Undergraduate)

Potential transfer students should refer to the guidelines as shown on pages 15 and 33 of this catalog. The faculty of the Civil and Environmental Engineering Department has established its own additional requirements and interpreted the University guidelines as follows:

The 136-credit curriculum approved by ABET is fulfilled through a combination of transfer credits, credits by examination and course credits completed at Polytechnic. Transfer credits for courses in mathematics, physics, chemistry, the humanities and social sciences are evaluated by the Admissions Office with the guidance of the faculty of the individual departments.

The length of time for a transfer student to complete the degree requirements will depend on the following factors:

a) the number of transfer credits awarded

b) the particular courses required to complete the degree requirements

c) enrollment status, i.e. full-time or part-time

In general as part of the 136 credit curriculum, students from accredited schools must complete a minimum of 24 credits at Polytechnic with a civil engineering designation as indicated below:

<table>
<thead>
<tr>
<th>Junior Year (Day)</th>
<th>Senior Year (Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 322 1st term</td>
<td>CE 252 1st term</td>
</tr>
<tr>
<td>CE 323 2nd term</td>
<td>CE 332 2nd term</td>
</tr>
<tr>
<td>CE 331</td>
<td>CE 342</td>
</tr>
<tr>
<td>CE 340</td>
<td></td>
</tr>
</tbody>
</table>

Because of the sequential nature of these courses, four successive semesters are usually required. Additional credits may be required, as determined by the transfer credit evaluation, to complete the bachelor's degree requirements. International students holding degrees from schools in their own countries are required to fulfill these requirements to earn a Polytechnic bachelor's degree.

Transfer students from schools with 2-year AAS degree programs in Engineering Science can normally expect to complete the bachelor's degree requirements within two years, with appropriate summer school coursework immediately before the junior year.

Students from 2-year technology programs are granted transfer credits according to the schools from which they come. With careful planning, it is generally possible to complete the necessary work in three years, including summer school coursework.

EVENING SESSION

Prospective students planning to earn a degree on a part-time evening basis should contact an undergraduate adviser for details about this plan before enrolling. Most upper-level evening courses will be offered on an alternate-year basis and may be integrated with the day program using a late afternoon schedule. Sample programs are shown for both full-time and part-time study.
## 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>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>MA</td>
<td>101 Calculus I</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>CM</td>
<td>101 General Chemistry IIA</td>
<td>2½</td>
<td>0</td>
</tr>
<tr>
<td>CM</td>
<td>111 General Chemistry Lab IIA</td>
<td>0</td>
<td>1½</td>
</tr>
<tr>
<td>PH</td>
<td>101 Introductory Physics I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>HU</td>
<td>101 Writing and the Humanities</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>AM</td>
<td>101 Graphics</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>PE</td>
<td>101 Physical Education</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Sophomore Year

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
</tr>
<tr>
<td>MA</td>
<td>103 Calculus III</td>
</tr>
<tr>
<td>PH</td>
<td>103 Introductory Physics III</td>
</tr>
<tr>
<td>AM</td>
<td>116 Engineering Mechanics I</td>
</tr>
<tr>
<td>CE</td>
<td>151 Surveying</td>
</tr>
<tr>
<td>HU</td>
<td>110 Basic Report Writing</td>
</tr>
<tr>
<td>PE</td>
<td>103 Physical Education</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Junior Year

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>214 Computer Techniques in Engineering</td>
</tr>
<tr>
<td>CE</td>
<td>222 Fluid Mechanics</td>
</tr>
<tr>
<td>CE</td>
<td>322 Theory of Structures I</td>
</tr>
<tr>
<td>CE</td>
<td>351 Highway &amp; Transportation Engg. (Second Semester in Farmingdale)</td>
</tr>
<tr>
<td>AM</td>
<td>201 Thermodynamics I</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE</td>
<td>252 Reinforced Concrete Structures</td>
</tr>
<tr>
<td>CE</td>
<td>317 Foundations</td>
</tr>
<tr>
<td>CE</td>
<td>341 Environmental Engineering I</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
</tr>
<tr>
<td></td>
<td>Technical electives</td>
</tr>
<tr>
<td>CE</td>
<td>305 Engineering Contracts &amp; Specifications</td>
</tr>
<tr>
<td>CE</td>
<td>332 Design of Structural Systems</td>
</tr>
<tr>
<td>CE</td>
<td>342 Environmental Engineering II</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
</tr>
<tr>
<td></td>
<td>Technical electives</td>
</tr>
</tbody>
</table>

Minimum total credits required for graduation: 136

*This elective shall be of college level material beyond MA 102*
# Civil and Environmental Engineering

## Sample Eight-Year Program Leading to the Bachelor of Science Degree in Civil Engineering

### First Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing and the Humanities I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>7</td>
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</table>

### Second Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 103</td>
<td>Calculus III</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PH 102</td>
<td>Introductory Physics II</td>
<td>3½</td>
<td>1½</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>HU 110</td>
<td>Basic Report Writing I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>10</td>
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</table>

### Third Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM 111</td>
<td>Engineering Mechanics I</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2½</td>
<td>0</td>
<td>2½</td>
<td></td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab I</td>
<td>0</td>
<td>1½</td>
<td>1½</td>
<td></td>
</tr>
<tr>
<td>AM 101</td>
<td>Mathematics elective</td>
<td>3</td>
<td>0</td>
<td>3</td>
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</tr>
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</table>

### Fourth Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 202</td>
<td>Mechanics of Materials</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>EE 370</td>
<td>Principles of E.E.</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
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</table>

### Fifth Year**†

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 214</td>
<td>Computer Techniques in Engineering</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>AM 201</td>
<td>Thermodynamics I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>HU 102</td>
<td>Main themes in Contemporary World History</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

### Sixth Year**

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 151</td>
<td>Surveying Fieldwork</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

### Seventh Year**†

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 341</td>
<td>Environmental Engineering I</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CE 351</td>
<td>Highway &amp; Transportation Engg.</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tech.</td>
<td>Technical elective</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

### Eighth Year**

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 252</td>
<td>Reinforced Concrete Structures</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>CE 317</td>
<td>Foundations</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Tech.</td>
<td>Technical elective</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>9</td>
</tr>
</tbody>
</table>

Minimum total credits required for graduation: 136

* This 2-week course is offered every May during the day.

†† Offered in alternate odd years, i.e., 1987-1988, 1989-1990. (The fifth and sixth years are interchangeable.)
GRADUATE STUDIES

Programs of study are offered leading to degrees of master of science in civil engineering, master of science in environmental health science, engineer in civil engineering, doctor of philosophy in civil engineering, and the undesignated degree of doctor of philosophy in environmental health science.

The department has applied for permission to offer a program leading to the degree of master of science in environmental engineering. Details are available from the department head.

Requirements for the master’s degree include prescribed courses and approved elective courses. A project must be completed; a thesis may be substituted for elective courses. A minimum of 36 units is required for the degree.

Engineer degrees are 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.

Ph.D. degrees require 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 master’s degrees 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. Students should consult with the department head to determine the expected scheduling of such courses. More detailed requirements are described in the first part of this catalog and in The Civil Engineering Graduate Manual, which is available from the department office.

M.S. PROGRAM IN CIVIL ENGINEERING

M.S. programs are offered with majors in the following specialty areas: structural engineering, water resources and hydraulic engineering, water quality engineering, public works engineering-infrastructure, and geotechnical engineering.

Students interested in highway engineering or construction engineering and management may take the public works-infrastructure program with appropriate elective courses and a suitable project.

CIVIL AND ENVIRONMENTAL ENGINEERING

<table>
<thead>
<tr>
<th>Departmental Requirements</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 780</td>
<td>Analysis of Uncertainty in Civil Engineering</td>
</tr>
<tr>
<td>CE 996</td>
<td>Project for the Degree of Master of Science</td>
</tr>
</tbody>
</table>

Required Major Courses

Five courses in structural engineering, water resources and hydraulic engineering, water quality engineering, public works engineering-infrastructure, or geotechnical engineering 15

Major Electives

At least 6 units of approved courses in civil and environmental engineering 6

Other Approved Electives

At Least 9 units of approved graduate courses TOTAL 9

Major Requirements

Structural Engineering

CE 601 Theory of Structural Analysis and Design 3
CE 609 Matrix Methods of Structural Analysis I 3
CE 614 Metal Structures I 3
CE 625 Structural Dynamics 3
CE 641 Reinforced Concrete Structures I 3 15

Water Resources and Hydraulic Engineering

CE 715 Open Channel Hydraulics 3
CE 716 Hydraulic Problems 3
CE 722 Hydrology 3
CE 781 Formulation & Analysis of Public Works Projects 3

At least one of the following -

CE 711 Hydraulic Design of Structures 3
CE 725 Water Resources Mathematical Modeling 3
CE 732 Coastal Engineering 3 15

Water Quality Engineering

CE 738 Sanitary Chemistry 3
CE 740 Sanitary Microbiology 3
CE 742 Water & Wastewater Treatment I 3
CE 743 Water & Wastewater Treatment II 3
CE 747 Analysis of Stream & Estuary Pollution 3 15

Public Works Engineering - Infrastructure

CE 781 Formulation & Analysis of Public Works Projects 3
CE 791 Infrastructure Systems Analysis 3
CE 732 Infrastructure Design & Management 3
CE 801 Flexible Pavements - Design and Evaluation 3
CE 806 Highway Capacity and Traffic Analysis 3 15

75
CIVIL AND ENVIRONMENTAL ENGINEERING

Geotechnical Engineering

<table>
<thead>
<tr>
<th>No.</th>
<th>Courses</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 851</td>
<td>Earth Pressure &amp; Retaining Structures</td>
<td>3</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>CE 871</td>
<td>Foundation Engineering I</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 752</td>
<td>Air</td>
<td>3</td>
</tr>
<tr>
<td>CE 738</td>
<td>Sanitary Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CE 742</td>
<td>Water &amp; Wastewater Treatment I</td>
<td>3</td>
</tr>
<tr>
<td>CE 743</td>
<td>Water &amp; Wastewater Treatment II</td>
<td>3</td>
</tr>
<tr>
<td>CE 751</td>
<td>Environmental Health Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 752</td>
<td>Air Pollution</td>
<td>3</td>
</tr>
<tr>
<td>CE 770</td>
<td>Solid Waste Management</td>
<td>3</td>
</tr>
</tbody>
</table>

M.S. PROGRAM IN ENVIRONMENTAL HEALTH SCIENCE

<table>
<thead>
<tr>
<th>No.</th>
<th>Course</th>
<th>Departmental Requirement</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 996</td>
<td>Project for the Degree of Master of Science</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Environmental Health Science Requirements

<table>
<thead>
<tr>
<th>No.</th>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 738</td>
<td>Sanitary Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CE 740</td>
<td>Sanitary Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>CE 742</td>
<td>Water &amp; Wastewater Treatment I</td>
<td>3</td>
</tr>
<tr>
<td>CE 743</td>
<td>Water &amp; Wastewater Treatment II</td>
<td>3</td>
</tr>
<tr>
<td>CE 751</td>
<td>Environmental Health Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CE 752</td>
<td>Air Pollution</td>
<td>3</td>
</tr>
<tr>
<td>CE 770</td>
<td>Solid Waste Management</td>
<td>3</td>
</tr>
</tbody>
</table>

Approved Electives

At least 12 units of approved graduate courses

Minimum Total Units 36

REQUIREMENTS FOR THE ENGINEER DEGREE

A master's degree in civil engineering meeting the specialization 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. Engineer degrees may be earned in any area of specialization except environmental health science. The program follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 996</td>
<td>Project for the Degree of Engineer</td>
<td>12</td>
</tr>
<tr>
<td>CE 998</td>
<td>An approved elective in applied mathematics, or operations research</td>
<td>3</td>
</tr>
<tr>
<td>CE 999</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 with demonstrated scholastic ability may pursue a doctorate in civil engineering. In general, an applicant must hold a master's degree in civil engineering. For a doctorate in environmental health science, a master's degree in environmental health science is a prerequisite. Applicants with degrees in other fields may be admitted with deficiencies as evaluated by a departmental graduate adviser.

All doctoral students must complete a minimum of 90 units of work beyond the bachelor's degree or a minimum of 66 units beyond the master's degree. Of the units taken at Polytechnic, at least 27 must be formal course work (not including guided readings, seminars or projects). Ph.D. students must select a major field and two minor fields in consultation with the advisers.

To qualify as Ph.D. candidates, students must pass written and oral qualifying examinations. Registration for a minimum of 30 units of dissertation research is required. Registration should be continuous, until the dissertation has been completed and accepted.

Students interested in Ph.D. programs are advised to refer to the Civil Engineering Graduate Manual (available from the departmental office) for information on qualifying examinations and other regulations.

UNDERGRADUATE COURSES

CE 150 Surveying Fieldwork 2 credits
Field exercises involving the principles 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 3:0:3
Basic principles of stresses and strains of members subjected to direct force, torsion and bending. Deflections 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

CE 222 Fluid Mechanics 3:3:4
Fluid-flow concepts including continuity, energy and momentum equations, laminar and turbulent flow, boundary layer drag, dimensional analysis. Euler's equation 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
Physical and mechanical properties of concrete, metals, plastics and asphalts. Materials related to structural engineering. Experimental investigation of mechanical properties of selected structural materials and physical properties of cement and concrete mixes. Jointly developed and taught by civil and metallurgical engineering departments. Also listed under MT 303

CE 305 Engineering Contracts and Specifications 2:0:2
The preparation of contracts and technical specifications for engineering projects. Prerequisite: CE 202.

CE 317 Foundations 2:3:3
Site explorations and soil sampling; planning boring programs and interpretation of boring logs. Bearing capacities of footings and mats for granular soils and clays. Settlement of structures. Lateral earth pressure 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 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 plants for small communities. Introduction to air quality and solid waste problems. Prerequisites: CE 341 and CE 340.

CE 345 Hydraulic Engineering 3:0:3
Pumping systems, hydroelectric developments, nonuniform flow in open channels, Overflow, siphon and shaft spillways. Flow meters for open and closed conduits. Prerequisite: CE 222.

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 interection design, drainage, economic analysis and finance, rigid and flexible pavements, velocity profile and performance, evaluation, future developments. Prerequisite: CE 151.

CE 354-392 Bachelor's Thesis in Civil Engineering each 2 credits
Original research, design or plan for an approved engineering project. Thesis gives students the opportunity to apply knowledge and training gained in courses by approaching and successfully solving comprehensive problems. Conferences held regularly with an appointed member of the faculty. Thesis registration required each semester. Students must reregister for thesis until completed. Prerequisite: senior status.

CE 398 Civil Engineering Internship 2:0:2
Supervised, creative civil engineering work of at least two months' performance judged on the basis of written and oral reports presented to industrial and faculty supervisors. Regular faculty visits and conferences arranged during internships. Open to students who have completed their junior year and have departmental approval prior to beginning the internship experience. Prerequisite: department head's approval.

CE 398 Project in Civil Engineering 2 or 3 credits as arranged
Solution to civil engineering problem or detailed study of an advanced area of civil engineering under close supervision of an adviser. Before undertaking the project, interested students must submit a detailed written proposal of the problem they intend to investigate to the course director, along with the number of credits for which they wish to register. Results of the project must be submitted to the department as a formal report.

GRADUATE COURSES

GENERAL

CE 590 System Analysis for Civil Engineers 2:3:3
Review of optimization techniques and simulation and optimization models used to make policy decisions for civil engineering systems. Computer applications including facilities location, project sequencing and scheduling, capacity expansion, land use planning, and districting and scheduling of municipal services, optimal sewer system design, and reservoir operation.
CIVIL AND ENVIRONMENTAL ENGINEERING

CE 780 Analysis of Uncertainty in Civil Engineering 2.5:0:3
Brief review of basic concepts including problem identification, definitions of statistical parameters and principles of probability. Applications utilizing techniques of frequency distribution, regression and correlation, time series analysis, significance testing, elementary decision theory, sensitivity and risk analysis, reliability assessments. All topics emphasize applications to civil engineering practice and research, and include problem solving in such areas as hydrology, structures, geotechnical, transportation, and environmental engineering. Student specialty areas will be considered in selection of problems for study.

STRUCTURAL ENGINEERING

Prerequisites for all courses: MA 104, CE 323

CE 601 Theory of Structural Analysis and Design 2.5:0:3
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. Prerequisite: CE 252 and CE 331.

CE 603-604 Special Topics in Structural Analysis I, II 2.5:0:3
Specialized current topics of interest offered at irregular intervals by advance announcement. Graduate advisers may approve repeated registration for different topics. Prerequisite: CE 601.

CE 605 Plate and Shell Structures 2.5:0:3

CE 609 Matrix Methods of Structural Analysis I 2.5:0:3

CE 610 Matrix Methods of Structural Analysis II 2.5:0:3
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 2.5:0:3
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 613 Stability of Structures 2.5:0:3
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 601.

CE 614 Metal Structures I 2.5:0:3
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 2.5:0:3
Techniques for designing cable-suspended and cable-stayed structures, latticed 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 2.5:0:3

CE 617 Introduction to Modern Concepts of Structural Safety 2.5:0:3

CE 621 Advanced Mechanics of Material 2.5:0:3
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. Also listed under AM 611.

CE 625 Structural Dynamics 2.5:0:3

CE 627 Dynamic Response of Civil Engineering Structures 2.5:0:3
Description of dynamic loading on civil engineering systems. Effects of wind on bridges, suspension systems and tall buildings using random vibration theory. Earthquake analysis of structures responding elastically. Applications to problems in material behavior such as fatigue in cables, hysteresis loops in concrete and steel and damping in structural systems. Prerequisite: CE 625.

CE 632 Introduction to Piping Analysis 2.5:0:3
Use of displacement energy, complementary energy and thermodynamic reciprocal theorem in solution of problems of plane bending of rings, frames and piping; three-dimensional analysis of piping systems; computational methods of analysis concepts of elastic center; bending of bimetales and layered elements. Prerequisites: AM 601 or equivalent. Also listed under AM 632.

CE 641 Reinforced Concrete Structures I 2.5:0:3
Elastic and ultimate strength design of reinforced concrete members. Stress 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 2.5:0:3
WATER RESOURCES AND HYDRAULIC ENGINEERING

Prerequisite for all courses: MA 104, CE 222

CE 711 Hydraulic Design of Structures 2 1/2:0:3
Hydraulic principles utilized in design of structures such as spillways, measuring flumes, energy dissipators, channels of linear and nonlinear alignment, gradual and sudden transitions in subcritical and supercritical flow, culverts, lateral spillway channels. Co/Prerequisite: CE 715.

CE 715 Open Channel Hydraulics 2 1/2:0:3
Theory and computations for uniform flow, gradually varied flow, rapidly varied flow, unsteady flow in prismatic and non-prismatic channels.

CE 718 Hydraulic Problems 2 1/2:0:3
Similarity, dimensional analysis and modeling techniques as applied to hydraulic systems. Pumping systems including hydraulic transients and flow of air, liquids, sludge. Cavitation. Co/Prerequisite: CE 715.

CE 717 Hydrodynamics for Civil Engineers 2 1/2:0:3
Applications of basic concepts of fluid kinetics and dynamics to problems in turbulent diffusion, density currents, stratified flows and other problems of special interest to civil engineers.

CE 722 Hydrology 2 1/2:0:3
Hydrologic cycle. Meteorological considerations. Analyses of precipitation, runoff, unit hydrograph, flood routing and reservoir storage. Principles of groundwater hydrology. Introduction to frequency analysis of floods and droughts. Prerequisite: undergraduate degree in engineering or science.

CE 725 Water Resources Mathematical Modeling 2 1/2:0:3
Studies of hydraulic, hydrologic, water quality and systems models as applied to rivers and streams, embayments, estuaries 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. Prerequisite: coursework in computer programming and Co/Prerequisite: CE 715.

CE 723 Coastal Engineering 2 1/2:0:3
Basic concepts of wind-wave induced phenomena in near shore areas as associated with problems of shoreline protection. Water-wave dynamics as applied to coastal structures, including effect of hurricanes on maximum storm tides, wave heights, pressures.

CE 733 Forces on Marine Structures 2 1/2:0:3
Analysis of forces on marine structures such as piers, platforms, jetties, subjected to hydrodynamic and other loads. Waves as random processes. Applications of wave forecasting and spectral analysis. Description of interactions between wave forces and structural responses.

CE 734 Design of Marine Structures 2 1/2:0:3
Planning of port facilities and coastal protection. Problems involved in design of marine structures. Choice of design parameters affected by hydrodynamic and other loads.

CIVIL AND ENVIRONMENTAL ENGINEERING

CE 735-738 Special Topics in Water Resources and Hydraulic Engineering I, II 2 1/2:0:3
Topics in water resources and hydraulic engineering including hydroeconomic models, finite difference and finite element models, synthetic hydrology, conjunctive use of surface water and ground water, desalinated and recycled water, thermohydrologic and hydrometeorologic problems; flushing of estuaries; hydrodynamics 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
Review and applications of principles of chemistry to waters and wastewaters. Laboratory analysis of representative waters and wastewaters for most commonly determined parameters as related to applications in water environment. Evaluations of methods and procedures.

CE 740 Sanitary Microbiology 1:2:3
Lectures and laboratory work. Microbiology of wastewater treatment processes, wastewaters, receiving waters. Microorganisms and ecological relationships. Laboratory includes identification and microbiological examination of waters and wastewaters.

CE 742 Water and Wastewater Treatment I 2 1/2:0:3
Physical, chemical and biological principles involved in process design and treatment of water and wastewater. Topics include aeration, filtration, softening, chemical treatment, coagulation, flocculation, desalination, taste and odor control. Co/Prerequisite: CE 738.

CE 743 Water and Wastewater Treatment II 2 1/2:0:3
Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. Prerequisite: CE 740.

CE 745 Water and Wastewater Treatment Laboratory 1:2:3
Laboratory processes 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 waste. Co/Prerequisite: CE 743.

CE 746 Industrial Waste Treatment 2 1/2:0:3
Sources of industrial wastewaters and their treatability by physical, chemical and biological processes. Problems and solutions involved in combining municipal and industrial waste treatment. Status of government regulations imposed on industries in prevention of water pollution.

CE 747 Analysis of Stream and Estuary Pollution 2 1/2:0:3
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 2 1/2:0:3
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 2 1/2:0:3
CIVIL AND ENVIRONMENTAL ENGINEERING

CE 758 Air Pollution Engineering Control 2 1/2:0:3
Pollutant emissions control; analysis of pollutant properties, concentrations and boundary conditions; absorptive, and reactive recovery processes for moving and stationary sources; formation and removal of gaseous oxides (NO, SO, CO, etc.) and of aerosols and other particulates. Prerequisite: Instructor’s permission. Also listed under CH 752.

CE 767 Environmental Impact Evaluation 2 1/2:0:3
An examination of legal and technical requirements in the preparation of environmental impact statements. 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 analysis, field evaluations, mitigations, hearing procedures and management. Practical examples and case studies used.

CE 770 Solid Waste Management 2 1/2:0:3
Engineering aspects of solid waste collection, transport and disposal, including incineration, sanitary landfill, composting, recovery and recycling, economic evaluation of factors affecting selection of disposal methods.

CE 771-772 Special Topics in Environmental Engineering I, II 2 1/2:0:3
Current topics including nitrication in natural and treated waters, hazardous and toxic wastes, organic removal from water supplies, water reuse, specialized aspects of biological wastewater treatment, environmental health, solid disposal, and modeling natural waters and treatment systems. Prerequisite: permission of the instructor.

PUBLIC WORKS ENGINEERING — INFRASTRUCTURE

CE 781 Formulation and Analysis of Public Works Projects 2 1/2:0:3
Methods for the identification, formulation, preliminary appraisal, and detailed analysis of individual projects and systems of civil engineering projects. Different approaches appropriate for government agencies, public utilities, industrial firms, and private entrepreneurs. Planning considers projects that satisfy single and multiple purposes and objectives, meet local and regional needs, and take advantage of opportunities for development. Financial and economic analyses, including sensitivity and risk analysis. Mathematical models for evaluation of alternatives and optimization. Impacts of projects: environmental, social, regional economic growth, legal and institutional, and public involvement.

CE 790 Fire Protection Engineering 2 1/2:0:3
Overview of fire problems in the United States. Statistics, trends and fire experiences of interest to engineers. Chemistry and physics of fire phenomena, including ignition, flammability, heat transfer, products of combustion and modes of fire growth and extension. Properties and behavior of materials at elevated temperatures. Performance of structures exposed to fire and failure mode analysis. Laboratory and full-scale testing of construction materials, components, assemblies and structures. Building codes, fire codes and standards. Measures for fire protection: detection, alarm and communication systems and systems for fire suppression and smoke control.

CE 791 Infrastructure Systems Analysis 2 1/2:0:3
Methodologies and procedures for macro-level analysis of engineered infrastructure systems. Introduction to computer-based techniques for optimization of design, operation and maintenance of infrastructure subsystems. Demographic, system loading and capacity analyses for water distribution, wastewater collection and disposal, solid wastes collection, street sweeping, snow removal and other municipal service systems. Infrastructure financing and capital budget process. Life cycle and benefit-cost analyses applied to infrastructure renewal. Prerequisite: CE 214 or equivalent.

CE 792 Infrastructure Design and Management 2 1/2:0:3
Design and use of geographic data base systems for inventory and planning. Algorithms for design of systems for the delivery of municipal services. Use of comprehensive, computer models for design, costing and management of infrastructure systems for fire protection, emergency health services, water supply, solid and liquid waste disposal, parks and recreation, energy delivery, and other urban services. Prerequisite: CE 214 or equivalent.

CE 793 Workshop on Infrastructure 2 1/2:0:3
Students undertake a comprehensive project involving the design of the engineered infrastructure for an urban community. Development of a computer data base, collection and organization of all necessary information for the planning, design, costing and development of a management system for each of several selected infrastructure subsystems. Alternative designs considered and life-cycle cost methods used to optimize investments. The course is taught by a faculty team from the Department of Civil Engineering. Prerequisite: CE 214 or equivalent.

CE 798-799 Special Topics in Infrastructure Systems and Construction I, II 2 1/2:0:3
Current topics of interest including methodologies and procedures for analysis of existing infrastructure systems, geographic information data and management systems, photogrammetric and remote sensing techniques and utilization and design of infrastructure facilities and systems. Intelligent buildings and other modern constructed works. Temporary structures for construction and problems in construction engineering. New approaches in construction management.

HIGHWAY ENGINEERING

Prerequisites for all courses: MA 104, CE 351

CE 801 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 802 Rigid Pavements: Design and Evaluation 2:1:3
Design and construction of rigid highway and airport pavements. Pavement performance and evaluation. Laboratory tests of plain and reinforced concrete pavements. Nondestructive testing techniques. Prerequisite: CE 252. Also listed under TR 721.

CE 804 Travel Demand Forecasting 2 1/2:0:3
Theory and application of travel forecasting methods to predict the amount and nature of travel on transportation systems. Co/Pre-requisite: TR 600 or equivalent. Also listed under TR 801.

CE 805 Traffic Engineering 1:3:3
Traffic engineering and its role in person movement. Traffic demand and its generation and management. Capacity analysis concepts and basic study techniques. Substantial treatment of intersections, arterials, and arterial management. Laboratory emphasis on field procedures and on the use of analysis procedures, including personal computer applications. Also listed under TR 791.

CE 806 Highway Capacity and Traffic Analysis 1:3:3
CE 810 Urban Planning Principles 2 1/2:0:3
A survey of contemporary theory and methods of the planning function.
Also listed under TR 630

CE 812 Transportation Economics and Finance 2 1/2:0:3
Also listed under TR 750

CE 821 Design of Traffic Facilities 2 1/2:0:3
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 TR 710

CE 840 Planning and Design of Terminals 2 1/2:0:3
Passenger and freight terminals with emphasis on system descriptions of these facilities. Land, marine, and air terminals. Methods are discussed for determining the levels of service for pedestrian flows. TOPO and truck terminals are also covered.
Also listed under TR 670

CE 841 Airport Planning and Design 2 1/2:0:3
Techniques for forecasting air passenger traffic and aircraft operations at commercial and general aviation facilities. Principles and practices for 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

CONSTRUCTION MANAGEMENT

CE 825 Construction Administration 2 1/2:0:3
Management problems unique to the construction business including licensing, bonding, insurance, short-term financing, and employee relations.
Also listed under MG 825

CE 826 Construction Estimates and Costs 2 1/2:0:3
Estimates, costs from the 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 the construction industry; legal problems in preparing and administering construction contracts. Prerequisite: CE 825.
Also listed under MG 827

GEOTECHNICAL ENGINEERING

Prerequisites for all courses: MA 104, CE 232, CE 317

CE 851 Earth Pressures and Retaining Structures 2 1/2:0:3
Conjugate stress relationships in infinite slopes in granular and cohesive soils. Studies of classical works of Rankine, Coulomb, Kersten and others for determining pressure distributions on rigid structures retaining soil masses. Effects of ground water seepage, surcharge loading. Analysis and design of rigid-type retaining structures and sheet piles. Soil reinforcement applications for retaining structures.

CE 853 Analysis and Design of Earth and Rockfill Dams 2 1/2:0:3
Importance of dams, selection of type, hydrological and geological considerations, design aspects of earth and rockfill dams, stability analysis, seismic stability, displacement treatment, ecological and environmental aspects.

CE 854 Engineering Geology 2 1/2:0:3
Importance of geology to civil engineers, case studies, rock formations, types of rocks, weathering of rocks, folds, faults, landslides, earthquakes, geological explorations and mapping, applications of geology in civil engineering projects such as dams, reservoirs, highways, tunnels and rock mechanics.

CE 881 Soil Mechanics I 2 1/2:0:3
Studies 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, consolidation of soils.

CE 882 Soil Mechanics II 2 1/2:0:3
Strength of soils, laboratory tests, effective stress parameters, total and effective stress paths, applications of soil strength in stability analyses of embankments, constitutive relations for soils. Prerequisite: CE 851.

CE 888 Experimental Soil Mechanics 1 2:0:3
Critical evaluation of standard testing procedures for identification and classification tests. Detailed examinations of permeability, capillarity and seepage phenomena using soil samples and electric analogs. One-dimensional consolidation test. Treatment of shear strength and the static triaxial compression test and its several variations. Special tests. Prerequisite: CE 861.

CE 871 Foundation Engineering I 2 1/2:0:3

CE 872 Foundation Engineering II 2 1/2:0:3
Settlement studies with attention to elastic, primary and secondary settlements. Role of soils laboratory in providing necessary soil parameters. Analysis and design of single piles and pile groups. Pile driving, load capacity and settlement. Negative skin friction. Analysis and design of cofferdams, piles and caissons. Prerequisite: CE 871.

CE 861-882 Special Topics in Geotechnical Engineering and Foundation Engineering I, II 2 1/2:0:3
Current topics of interest including theoretical determination of pile capacities, sheet pile bulkheads and trench problems, stresses on tunnels, theoretical approaches to soil stability, refinements in settlement analysis, and soil reinforcement applications. Computer applications in foundation engineering. Soil structure interaction problems. Prerequisites: CE 861 or CE 861 or CE 871.

CE 880 Earthquake Engineering 2 1/2:0:3
Earthquakes, causes, distribution, intensity and magnitude, seismic zoning, measurement of ground motion, theory of vibrations, response spectrum theory, effects of earthquakes on soils and structures, design considerations.

CE 892 Soil Dynamics 2 1/2:0:3
CIVIL AND ENVIRONMENTAL ENGINEERING

CE 894 Marine Geotechnology 2 ½:0:3

GUIDED READINGS, SEMINARS, PROJECTS AND THESSES

Note: Students should obtain a copy of the Institute’s “Regulations on Format, Duplication and Publication of Reports, Theses and Dissertation” at the Office of Research and Graduate Studies.

CE 901 Guided Readings in Civil Engineering 3 units
Individual study of selected literature in civil engineering under guidance of a 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 3 units
Lectures on recent developments in civil engineering given by representatives from industry, other research and educational institutions, and Polytechnic graduate students and faculty.

CE 998 Project for Degree of Master of Science 3 units
Analytical, design or experimental studies in civil or environmental engineering under guidance of a faculty adviser. Written report required. Prerequisites: degree status and project adviser’s approval and department head’s approval.

CE 997 Thesis for the Degree of Master of Science each 3 units
Original investigation or design in the student’s principal field of study prepared under close supervision of a faculty adviser. Candidates must successfully defend thesis orally. Registration for a minimum total of twelve (12) units required. Maximum of 12 units counted toward degree. Prerequisite: 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 a faculty adviser. Emphasis on current techniques. Written report in prescribed format 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 demonstrating creativity and scholarship worthy of publication in recognized engineering journals. Candidates must successfully defend their thesis orally. Registration for minimum of 36 thesis units required prior to defense. Registration should be continuous at the rate of at least three units per term. Prerequisites: degree status, completion of qualifying examinations and thesis adviser’s approval.

FACULTY

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**Frank Fazio,** Lecturer  
B.S.C.E., New York University; Professional Engineer

**Kamal A. Gadalla,** Lecturer  
B.S.C.E., Alexandria University; M.S., Eng., Polytechnic Institute of New York; Professional Engineer

**Clifford Gordon,** Lecturer  
B.S.C.E., Missouri School of Mines; Professional Engineer

**William F. Graner,** Lecturer  
B.S.C.E., Ph.D., Polytechnic Institute of New York; M.C.E., New York University; Professional Engineer

**Paul W. Grosser,** Lecturer  
B.E., M.E., Stevens Institute of Technology; Ph.D., Polytechnic Institute of New York; Professional Engineer

**King Sen Heh,** Lecturer  
B.S.C.E., M.S.C.E., Polytechnic Institute of New York; E.D., Columbia University; Professional Engineer

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CIVIL AND ENVIRONMENTAL ENGINEERING

Irving J. Hirshman, Lecturer
B.Arch., New York University; Registered Architect

Thomas Lindvit, Lecturer
Professional Engineer; Land Surveyor

Edward E. Lockley, Lecturer
B.S.C.E., Polytechnic Institute of New York; M.S., M.P.A., Long Island University; Professional Engineer

Aristodimos J. Philippacopoulos, Lecturer
B.S. (Eng.), Aristotleion University (Greece); M.S.C.E., Ph.D., Polytechnic Institute of New York

Kevin J. Phillips, Lecturer
B.C.E., CCNY; M.S. (Env. Eng.), Massachusetts Institute of Technology; Ph.D., Polytechnic Institute of New York; Professional Engineer

Satinder P.S. Puri, Lecturer
B.S.C.E., Punjab University (India); M.S.C.E., University of Illinois; Professional Engineer

Gabriel D. Rossetti, Lecturer
B.S.C.E., New England College; M.S.C.E., M.S. (Management), Polytechnic Institute of New York; Professional Engineer; Professional Planner

Michael J. Sakala, Lecturer
B.S., Drexel University; M.S.C.E., Polytechnic Institute of New York; Professional Engineer

Sri K. Sinha, Lecturer
B.S.C.E., Patna University; M.S., CCNY; Professional Engineer

Andre Touma, Lecturer
B.S.C.E., Damascus University (Syria); M.S., Imperial College (England); Ph.D., Duke University; Professional Engineer

Jeffrey Vollmuth, Lecturer
B.S. (Marine Science), Southampton College (L.I.); M.S. (Environmental Engineering), George Washington University; Professional Engineer

Richard R. Zavesky, Lecturer
B.S.C.E., Rensselaer Polytechnic Institute; M.S.C.E., Ph.D., Polytechnic Institute of New York

Jacob D. Paz, Research Assistant Professor of Civil Engineering
B.S., Jewish Theological Seminary; M.S., C.W. Post College; Ph.D., Polytechnic Institute of New York

John T. Tanacredi, Research Associate
B.S., Richmond College; M.S., Hunter College
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 in 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 programs in computer engineering.

UNDERGRADUATE PROGRAM

The program in computers is 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 degree in computer science described in the present section of the catalog, or (b) the computer engineering option leading to the bachelor of science degree in electrical engineering described in the electrical engineering section of the catalog. 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, computer laboratory, etc.) courses; both programs also require essentially 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 32 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 Undergraduate Student Manual). Students with interest in both electrical engineering and computer science should consider the computer engineering option in electrical engineering.

HONORS PROGRAM

Full-time students in computer science may be admitted into a BS/MS Honors program which leads to simultaneous award of the Bachelor's and Master's degree in computer science. Depending on the student's preparation and objectives, completion of the two degrees may come as early as the end of the fourth year of study. Admission into the program is normally made at the start of the freshman year; however, special programs may be worked out for other students individually with the departmental honors adviser. Acceleration may be achieved through Advanced Placement, through Credit by Examination, and through summer coursework or research participation. The program is intended for students with outstanding academic records.

TRANSFER STUDENTS

Transfer students are accepted into the computer science BS program on the same basis described in the catalog under admissions. In addition, the division requires that at least 18 credits in computer science be taken at Polytechnic.

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.

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 a computer science 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 student whose performance in the first three years is outstanding will be named as a senior honor student and, in consultation with an adviser, is permitted to replace some of the required senior technical courses by other courses, usually more advanced, which are directed toward the student's professional goals.
### 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>Cr.</strong></td>
<td><strong>No.</strong></td>
</tr>
<tr>
<td>CS 112</td>
<td>Programming in Pascal</td>
<td>3</td>
<td>CS 204</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>4</td>
<td>MA 102</td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
<td>3</td>
<td>PH 102</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
<td>2.5</td>
<td>CM 102</td>
</tr>
<tr>
<td>CM 111</td>
<td>Chemistry Lab I</td>
<td>1.5</td>
<td>CM 112</td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing and the Humanities I</td>
<td>3</td>
<td>HU 200</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education</td>
<td>2</td>
<td>PE 102</td>
</tr>
<tr>
<td><strong>Total Credits:</strong></td>
<td>16</td>
<td></td>
<td><strong>Total Credits:</strong></td>
</tr>
</tbody>
</table>

### Sophomore Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 203</td>
<td>Computer Programming II</td>
<td>3</td>
</tr>
<tr>
<td>MA 104</td>
<td>Appl. Diff. Equations</td>
<td>3</td>
</tr>
<tr>
<td>PH 103</td>
<td>Introductory Physics III</td>
<td>2.5</td>
</tr>
<tr>
<td>HU 110</td>
<td>Basic Report Writing</td>
<td>3</td>
</tr>
<tr>
<td>PE 103</td>
<td>Physical Education</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total Credits:</strong></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

### Junior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 205</td>
<td>Ass'y &amp; Machine Lang</td>
<td>3</td>
</tr>
<tr>
<td>CS 237</td>
<td>Intro. to Computer Architecture</td>
<td>3</td>
</tr>
<tr>
<td>MA 223</td>
<td>Intro. to Probability</td>
<td>3</td>
</tr>
<tr>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td><strong>Total Credits:</strong></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 238</td>
<td>Operating Systems</td>
<td>3</td>
</tr>
<tr>
<td>CS 299</td>
<td>CS Elective</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Credits:</strong></td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

### 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 008 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 may be substituted on a zero-credit basis. Physical Education is waived for students who attend part-time for their first 64 credits, and for students who receive 64 transfers credits. The waiver is prorated when part-time attendance or transfer is less than 64 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 55 degree requirement.**
- **IS 140 - 141 may be substituted for HU 200 plus SS 104.**
- **Take specified HU, IS, LA, ML, or SS-inferred course with adviser approval.**
- **Students with superior mathematical aptitude may replace the MA 101 - MA 104 sequence with MA 111 - MA 114. Consult the Department of Mathematics about your eligibility and course availability.**

**Total credits required for graduation:** 128
DEPARTMENTAL STANDARDS AND PROBATION

To earn a BS degree in computer science, students must have a minimum C average (2.00 grade-point average) in the major consisting of the courses in computer science plus courses in other technical subjects. This requirement for a minimum technical average is above and beyond the University BS degree requirement for a minimum 2.00 grade-point average overall. Students below average, or deficient in a subject, will be placed on departmental probation as a warning that they are not acceptably progressing towards the degree. Continued inability to meet the conditions of probation may lead to academic disqualification from the BS (CS) degree program.

Probation action may be occasioned by a semester or cumulative technical average less than 2.00; grades lower than C in important courses, particularly CS 112/204; failure to adhere to course prerequisites; and excessive or unauthorized course withdrawals. Students on probation may be required to reduce their course load or restrict their extracurricular activities; they may be required to postpone an advanced course or to undertake a remedial course program; or they may be made to repeat courses passed with a grade less than C. Almost without exception, students earning D+, D or I in CS 112 or CS 204 will be asked to repeat the course. Likewise, a student with less than a C semester average, or with less than a C average in courses of a closely related sequence, may be asked to repeat courses in which grades were D+, D or I.

When a course is repeated, the second grade is required to be no lower than C. Failure to achieve this leads to disqualification from the program. Permission to try a course more than twice is granted only under exceptional conditions. The exclusion of the first grade of a repeated course in the computation of the technical grade-point average applies for a maximum of four such courses. If additional courses are repeated, all grades count, including the first.

Students on probation are usually permitted to preregister for the next semester, but they are obliged to consult their advisers after grades are posted, before the start of classes. Students who undertake courses in violation of their probation condition face deregistration and possible disqualification.

INFORMATION

The Undergraduate Student Manual, issued to every student, contains further details on honors, probation, approved electives, typical examples of minors, projects, and other matters of interest. Curricula and prerequisite changes, new courses, special sections, and other last minute announcements are posted on the bulletin boards outside the computer science office in Brooklyn and the departmental office in Farmingdale. Each student is responsible for keeping informed.

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, database 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 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 research fellowships, teaching fellowships 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 required. 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 MS 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, C, 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 BS degrees in computer science as well as students with degrees in technical areas from an accredited institution and strong minors in computer science will satisfy the entrance requirements for the MS degree programs.

Students having superior academic credentials but lacking sufficient background are admitted in conditional status pending satisfactory completion of additional preparatory courses as specified from undergraduate computer-science courses and/or from the series of six graduate orientation courses, CS 530, CS 540, CS 550, CS 560, CS 580, and CS 590. Successful completion of the preparatory courses with a B or better grade in each course is a necessary condition for transfer to graduate status. No student will be admitted to full-time conditional status who lacks the equivalent of CS 530.
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 regular status. Foreign students and others for whom English is a second language may be required to undertake preparatory work to improve their language skills before admission into the graduate program.

Admission with advanced standing is accepted in accord with Polytechnic regulations published elsewhere in this catalog. A maximum of nine units may be applied to the MS degree for previous graduate work at an acceptable institution.

DEGREE REQUIREMENTS

To satisfy the requirements for the master's degree, the student must complete a total of 36 units as described below, with 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 a graduate adviser is required.

MASTER OF SCIENCE
(COMPUTER SCIENCE)

1. Core Requirements (B average required) 15
   - CS 603 Design and Analysis of Algorithms I
   - CS 675 Theory of Computation
   - MA 821 Numerical Analysis

2. One of the following three courses: 3
   - CS 675 Theory of Computation
   - MA 821 Numerical Analysis
   - 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 of Algorithms I, II
   - CS 606, 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 691, CS 692 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 may be earned toward the degree. 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) 27

Required Courses
   - CS 603 Design and Analysis of Algorithms I
   - CS 606 Software Engineering I
   - CS 608 Principles of Database Systems
   - CS 609 Information Analysis and System Design I
   - CS 623 Operating Systems I
   - IE 600 Engineering Economy
   - 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 from each of the following groups:
   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 given evidence of ability for independent scholarly work may consider extending their goals toward the degree of doctor of philosophy. The requirements for admission to the program include the following:

1. A BS degree in science, engineering or management from an accredited school and a superior academic record.

2. An MS 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 BS degree, including 24 units of dissertation.

2. Qualitative rather than quantitative considerations will determine the final approval of the program of graduate study; however, the following should be included:
   a. The basic MS requirement in computer science;
   b. A major concentration in a computer science area;
   c. Supporting courses in non-computer areas, for breadth;
   d. A minor concentration in an area other than computer science (a minimum of four courses).
Computers and programming; use of grams. (Last offered spring, 1987.)

Types of tions, function and subroutine procedures. Methods for the design of high structured programs. Character and bit strings, arrays, records, sets and structures.

Recursion, searching and sorting. Pointers, and dynamic data bases access. Dynamic allocation of storage. Manipulation of strings. Prerequisite: CS 112.

CS 205 Assembly and Machine Language Programming 3:0:3

CS 206 Compilers 3:0:3
Grammars, lexical analyses, parsing algorithms, intermediate languages, 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 ANS-COBOL for simple and complex business problems. Structured programming used throughout. Creating, using 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. (Cannot be used to satisfy any degree requirements in computer science or in electrical engineering.) Prerequisites: CS 100 or CS 112.

CS 230 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 112.

CS 236 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 hard wired and microprogrammed control. Prerequisite: CS 235.

CS 238 Operating 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 Computer Music 3:0:3
Introduction to sound synthesis: frequency spectra, Fourier series and transforms, filtering, sampling, A/D and D/A conversion. Synthesis techniques: additive, subtractive, and FM synthesis; oscillators and envelope generators; computational requirements. Digital synthesizers and interfaces to microcomputers. Interactive composition languages: systems for sound file editing, mixing and playback. Control of musical microstructure; interaction via gesture; psychoacoustical effects. Composition on the Music I system. Prerequisites: MA 104, some knowledge of programming, interest in music.

CS 288 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. Prerequisites: EE 377 and CS 236; co/prerequisite: CS 237.

General Prerequisite: Students may not register for any junior- or senior-level courses until their freshmen requirements are completed.

CS 100 Introduction to Computer Programming 2:0:2
Introduction to computers to develop fundamental understanding of their use. Early 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. (Cannot be used to satisfy any degree requirements in computer science or in electrical engineering.)

CS 111 Computer Programming I 3:0:3
Types of languages, problem-solving, algorithms, flow charts. Basic PL/1 instructions, simple programs, programming style, structured programs. Character and bit strings, arrays, built-in functions, function and subroutine procedures. Problems assigned from several disciplines solved on the Polytechnic computer. (Last offered fall, 1986.)

CS 112 Programming in Pascal 3:0:3
Computers and programming; use of terminals; problem solving, simple programs and program structure; control statements and procedures; data types; Functions: Arrays, records, sets and files. Recursion, searching and sorting. Pointers, and dynamic data structures.

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. (Last offered spring, 1987.) Prerequisites: CS 111 and MA 101.

CS 204 Introduction to Data Structures 3:0:3
Mathematical models and computer representations. Operations on arrays, stacks, queues, sequential and linked representations, linear data structures, trees and graphs. Sorting and searching, Data structure access. Dynamic allocation of storage. Manipulation of strings. Prerequisite: CS 112.

CS 205 Assembly and Machine Language Programming 3:0:3

CS 206 Compilers 3:0:3
Grammars, lexical analyses, parsing algorithms, intermediate languages, 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 ANS-COBOL for simple and complex business problems. Structured programming used throughout. Creating, using 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. (Cannot be used to satisfy any degree requirements in computer science or in electrical engineering.) Prerequisites: CS 100 or CS 112.

CS 230 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 112.

CS 236 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 hard wired and microprogrammed control. Prerequisite: CS 235.

CS 238 Operating 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 Computer Music 3:0:3
Introduction to sound synthesis: frequency spectra, Fourier series and transforms, filtering, sampling, A/D and D/A conversion. Synthesis techniques: additive, subtractive, and FM synthesis; oscillators and envelope generators; computational requirements. Digital synthesizers and interfaces to microcomputers. Interactive composition languages: systems for sound file editing, mixing and playback. Control of musical microstructure; interaction via gesture; psychoacoustical effects. Composition on the Music I system. Prerequisites: MA 104, some knowledge of programming, interest in music.

CS 288 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. Prerequisites: EE 377 and CS 236; co/prerequisite: CS 237.

UNDERGRADUATE COURSES

Students are advised to consult the departmental Undergraduate Student Manual and the Schedule of Classes for changes in courses, course content and prerequisites in effect after publication of this catalog.
COMPUTER SCIENCE

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 237 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 and relational structures. Practical applications of state-of-the-art techniques, foundations and underlying theories. Prerequisite: CS 204.

CS 318 Microprocessors 3:0:3
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 203 and CS 297.

CS 397 Senior Seminar and Project in Computer Science 2:0:2
Topics of general interest prepared, reported and discussed by faculty and students. Project proposals prepared and presented by students. Prerequisites: CS 206 and CS 298 (Last offered Fall 1986).

CS 399 Senior Project in Computer Science 1:6:3
Term project. Several students work as a group with a staff member and graduate students on a topic of interest. Written report and presentation required. Prerequisite: CS 397. Corequisite: CS 299.

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 2:1:0:3
Computers and programming; use of terminals; problem solving, simple programs and program structure; control statements and procedures; data types. Functions. Arrays, records, set and files. Recursion, searching and sorting. Pointers and dynamic data structures. Prerequisite: graduate status.

CS 540 Elements of Data Structures 2:1:0:3
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 2:1:0:3

CS 560 Introduction to Logic and Automata 2:1:0:3

CS 580 Introduction to Computer Architecture 2:1:0:3
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 555.

CS 590 Introduction to Operating Systems 2:1:0:3
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 540, CS 555, and CS 580.

GRADUATE COURSES

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 Mailing, 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 2:1:0:3
First course in computing concentrating on analysis of problems for computer solution. Organization of computers. Structure and properties of algorithms and programs, flow charting, debugging and verification, documentation, data representation, numerical errors. FORTRAN IV language used. (No credit will be allowed toward graduate degrees in computer science, information systems or other degree programs administered by the Department of Electrical Engineering and Computer Science.) Prerequisite: graduate status.

Also listed under IE 601.
CS 603 Design and Analysis of Algorithms I

CS 604 Design and Analysis of Algorithms II

CS 605 Software Engineering I
Software development, modeling tools. Techniques: design estimation, testing, reliability, management. Design and analysis: top-down, modular structured, HIF0 diagrams, cause-effect graphs. Probabilistic models: complexity, number of errors, exhaustive regression. Management: costs, productivity, controls. Prerequisites: MA223 and one of the following: CS 603, CS 623, CS 641.

CS 607 Software Engineering II
A continuation of material begun in CS 606 with emphasis on software development tools and the management of software projects including: prediction, estimation, and control of software costs and program productivity. Students will be organized into project groups and will plan and design a software system using manual and computerized development tools. Class presentations, exams and term project. Prerequisite: CS 606.

CS 608 Principles of Database Systems

CS 609 Information Analysis and System Design I
Introduction to the system life cycles of a computer information system. System life cycle management. Basic analytic tools, determining system economics. Logical system design. Introduction to physical system design. Prerequisite: graduate status and CS 630.

CS 610 Information Analysis and System Design II

CS 613 Computer Architecture I
Introduction to digital computer organization and architecture. Arithmetic operations: adders, accumulators, multipliers, dividers; organization and control of computer, mini-computer architecture; machine languages and systems principles. (Knowledge of a programming language required). Prerequisites: graduate status and CS 550, CS 580.

CS 614 Computer Architecture II
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 616 Microprocessors
Advanced microprocessor architectures and I/O techniques including multiprocessor systems, memory management, and real-time considerations. VLSI implementation, bit-slice microprogrammed systems. Prerequisite: CS 613.

CS 622 Operating Systems I
Introduction to the structure of multiprogramming computer operating systems. Memory hierarchies, memory management, static and dynamic including paging and segmentation, concurrency, sharing and synchronization. Prerequisites: graduate status.

CS 624 Operating Systems II
Continuation of CS 623. Overview of multiprogramming operating systems, processor and management (scheduling), deadlock detection and avoidance, file system management. Prerequisite: CS 623.

CS 627 Performance Evaluation of Computer Systems
Modeling and performance analysis of computer systems. Introduction to queueing network models and elements of queueing analysis. Exact and approximate analytic techniques, simulation and operational analysis. Examples in modeling multiprogramming operating systems, interactive systems, and flow control in computer networks. Prerequisite: EL 531 or MA 223 and instructor's permission.

CS 633 Information Retrieval and Natural Language Processing

CS 635 Principles of Communication Networks

CS 637 Programming Languages
The structures, notations, and semantics of conventional programming languages. Introduction to analysis and design of user-oriented application languages. Advanced concepts of input and output. Prerequisites: graduate studies and CS 540, CS 550.

CS 641 Compiler Design and Construction I
Organization of compiler, symbol table organization, lexical analysis, syntax analysis, object code generation, introduction to code optimization techniques. Internal representations of parsed source program, Polish notation, triples, trees. Translation of arithmetic expressions and programming constructs. Prerequisites: graduate status and CS 540, CS 550, and CS 560.

CS 642 Compiler Design and Construction II
Further considerations of code optimization techniques. Formal languages and grammars. Introduction to translator systems. Prerequisite: CS 641.

CS 651 Computer Graphics and Image Processing
Introduction to computer graphics. Vector, curve, and character generation. Display components and algorithms, data structures. Discussion of digital image processing, digitization, enhancement, encoding and representation techniques. Prerequisite: CS 613.
COMPUTER SCIENCE

CS 653 Interactive Computer Graphics 2 1/2:0:3

CS 661 Artificial Intelligence I 2 1/2:0:3

CS 662 Artificial Intelligence II 2 1/2:0:3

CS 671 Switching and Automata I 2 1/2:0:3
Analysis and synthesis of combinational and sequential switching circuits. Boolean algebra, switching functions, minimization, single and multiple output networks, realization of functions. Finite-state sequential machines, state-transition diagrams, machine and state equivalence, incompletely specified machines, state reduction, machine realizations. Prerequisite: graduate status and CS 560.

CS 672 Switching and Automata II 2 1/2:0:3
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 conservation, diagnosing and homing experiments, machine identification and testing. Prerequisite: CS 671.

CS 673 Formal Languages and Automata Theory 2 1/2:0:3
Introduction to generative grammars, characteristics of regular, context-free, context-sensitive and type-zero grammars. Relationships between languages and machines. Finite-state machines, pushdown automata, Turing machines. The halting problem, solvable and unsolvable linguistic questions. Prerequisite: CS 671.

CS 675 Theory of Computation 2 1/2:0:3
Aspects of mathematical logic with emphasis on applications to computing machines. The Resolution Principle as applied to propositional and first-order logic. Theorem proving. Correctness of programs. Applications to computer architecture, algorithms, compilers, languages. Measures of program complexity. Prerequisite: graduate status and mathematical maturity.

CS 681 Information Privacy and Security 2 1/2:0:3
Introduction to security and privacy issues associated with information systems. Cost-risk tradeoffs. Technical, physical, and administrative methods of providing security. Control of access through technical and physical means. Identification and authentication. Encryption, including the Data Encryption Standard (DES) and public key systems. Management of encryption systems, including key protection and distribution. Privacy legislation and technical means of providing privacy. Prerequisite: graduate status.

CS 901-912 Selected Topics in Computer Science each 2 1/2:0:3
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 advisor's approval.

CS 941-942 Readings in Computer Science I, II each 2 1/2:0:3
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 of graduate study and who are available for weekly consultation with an advisor. An examination or term report is required. Prerequisite: regular status and permission of director of division.

CS 996 Advanced Project in Computer Science 2 1/2:0:3
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 advisor is required before registration. An oral examination on the project report is required. Prerequisite: regular status.

CS 997 Thesis for Degree of Master of Science 3 units
Exceptional students may elect to write a master’s thesis for which no more than six units may be earned toward the degree. Such research should adequately 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 is required. Thesis registration must be continuous. Prerequisite: regular status and satisfactory grades in prescribed courses.

CS 999 Dissertation for Degree of Doctor of Philosophy 3 units
Original investigation of computer science problem. Must demonstrate creativity and include features of originality and utility worthy of publication in a recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: passing of qualifying examination and approval of the computer science division.

FACULTY

Donald Hockney, Professor of Computer Science and Director of the Division of Computer Science
B.A., McMaster University; Ph.D., Cornell University
Logic, data base systems

Aaron Kershenbaum, Professor of Computer Science
B.S., M.S., Polytechnic Institute of Brooklyn; Ph.D., Polytechnic Institute of New York
Computer communications, algorithms

Melvin Kleer, Professor of Computer Science
B.A., M.S., Ph.D., New York University
Programming systems, languages, and 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

Stanley Praiser, Professor of Mathematics and Computer Science
B.S., City College of New York; M.S., Ph.D., New York University
Numerical analysis, theory of computation, applied mathematics, software engineering

Henry Ruston, 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

Martin L. Shooman, Professor of Electrical Engineering and Computer Science
S.B., S.M., Massachusetts Institute of Technology; D.E.E., Polytechnic Institute of Brooklyn
Software engineering, system reliability and safety

Richard Van Slyke, Professor of Electrical Engineering and Computer Science and Director of the Center for Advanced Technology in Telecommunications
B.S., Stanford University; Ph.D., University of California (Berkeley)
Computer communications, telecommunications

Roy S. Freedman, Associate Professor of Computer Science
B.S., M.S. (EE), M.S. (Math), Ph.D., Polytechnic Institute of New York
 Artificial intelligence, expert systems

Andrew S. Noetzle, Associate Professor of Computer Science
B.E.E., City College of New York, Ph.D., University of Pennsylvania
Computer architecture, operating systems, signal processing, computer music

Linda Anne Grieco, Assistant Professor 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, Assistant Professor of Computer Science
A.B., Columbia University; M.S., Ph.D., Polytechnic Institute of New York
Coding theory, operating systems, high-level architecture

Evelyn Gail Roman, Assistant Professor of Computer Science
B.S., Ph.D., City College of New York
Artificial intelligence, robotics, applied mathematics

Alexander A. Stepanov, Assistant Professor of Computer Science
B.S., Moscow State University (U.S.S.R.); M.S., Moscow Institute of Education (U.S.S.R.)
Logic, artificial intelligence

Edward Kin-Ming Wong, Assistant Professor of Computer Science
B.E. (EE), S.I.U.N.Y., Stony Brook; Sc.M. (EE), Brown University; Ph.D. (EE), Purdue University
Artificial intelligence, robotics

Syed Ahamed, Visiting Professor of Computer Science
B.S. (EE), College of English (India); M.S. (EE), Indian Institute of Science (India); M.B.A., New York University; Ph.D., University of Manchester (England)
Computer graphics

Kenneth R. Aupperle, Academic Associate in Computer Science
B.S., M.S., Polytechnic Institute of New York
Microprocessor architecture

Harry Goldberg, Academic Associate in Computer Science
B.A., Queens College; M.S., Polytechnic Institute of New York
Data management, programming languages, natural language processing

Haldun Hadimioglu, Academic Associate in Computer Science
B.S., M.S., Middle East Technical University, (Turkey)
Computer Architecture

T. Michael Houlihan, Academic Associate in Computer Science
B.S., Catholic University of America; M.A. (Chemistry), University of Notre Dame; M.S. (CS), Polytechnic Institute of New York
Computer architecture, switching and automata

Philippe Poisson, Academic Associate in Computer Science
Dipl. de Technicien Superieur, Ecole Superieure de Technologie Electrique (France)
Parallel processing

Robert P. Signorile, Academic Associate in Computer Science
B.S. (Math), Queens College; M.S. (Quantative Analysis/Finance), New York University; M.S. (CS), Polytechnic Institute of New York
Information systems, computer networks

INDUSTRY PROFESSORS

Robert J. Flynn, Industry Professor
B.S., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Computer architecture; operating systems

Paul Friedland, Industry Professor
B.S. (Math); M.S. (CS), Pennsylvania State University
Computer software, database systems
COMPUTER SCIENCE

Jack Machanik, Industry Professor and Director of the Center for Digital Systems
B.Sc. (Engr.), 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

Maurice Karnaugh, Distinguished Adjunct Professor
B.S., City College of New York; M.S., Ph.D., Yale University

Maurice Karnaugh, Distinguished Adjunct Professor
B.S., City College of New York; M.S., Ph.D., Yale University

Fred Grossman, Adjunct Professor
B.S. (Math), Polytechnic Institute of Brooklyn; M.S. (Math), Ph.D. (GS), New York University

Robert Hong, Adjunct Professor
B.S., (IE) Columbia University; B.S. (EE), Cooper Union

J. Paul Roth, Adjunct Professor
B.M.E. University of Detroit; Ph.D. University of Michigan

Walter Vasilaky, Adjunct Professor
B.A., Rutgers University; M.A., University of Maryland; Ph.D., New York University

Arthur Appel, Adjunct Associate Professor
B.M.E., M.M.E., City College of New York

William Edelson, Adjunct Associate Professor
B.E.E., City College of New York; M.S., New York University; Ph.D., Polytechnic Institute of New York

Lewis Herzberg, Adjunct Associate Professor
B.E.E., City College of New York; M.S., Ph.D., Polytechnic Institute of Brooklyn

Robert O'Hara, Adjunct Associate Professor
B.A., Pennsylvania State University; M.S., Union College

Dimitris A. Protopapas, Adjunct Associate Professor
B.Sc., University of Athens (Greece); M.S.E.E., University of Toronto (Canada); Ph.D., Polytechnic Institute of New York

David Rozenstein, Adjunct Associate Professor
B.S., M.S., Ph.D., State University of New York (Stony Brook)

Wang-Chuan Tsai, Adjunct Associate Professor
B.S., M.S., National Chiao-Tung University (Taiwan); Ph.D., University of Illinois

Chihanand Apte, Lecturer
B. Tech. (EE) Indian Institute of Technology (Bombay, India); M.S., Ph.D. (CS) Rutgers University

Foster Betta, Lecturer
B.S., M.S., University of Connecticut; Ph.D., Stanford University

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

Philip S. Brown, Lecturer
B.S., City College of New York; M.S., Engineer, Polytechnic Institute of New York

Ximena Cardenas, Lecturer
B.S., M.S., Polytechnic Institute of New York

Fadi Chehade, Lecturer
B.S., Polytechnic Institute of New York; M.S. Stanford University

William Chuang, Lecturer
B.S., Chung-Yun College (Taiwan); M.S., Ph.D., Polytechnic Institute of New York

Denise Eng, Lecturer
B.S., M.S., Polytechnic Institute of New York

Daniel Gill, Lecturer
B.A., New York University; M.S., Polytechnic Institute of New York

Amine G. Kandalaft, Lecturer
B.S., M.S., Polytechnic Institute of New York

Clement R. Pizzo, Lecturer
B.S., West Virginia Institute of Technology; M.S. (EE), Engineer, Polytechnic Institute of New York

Semyon Shteingart, Lecturer
B.S., Ph.D., Polytechnic Institute of New York; M.S., University of Michigan

Ronald I. Sklar, Lecturer
B.A., Queens College; M.S. (Math), University of Connecticut; M.S. (CS), Polytechnic Institute of New York; Ed.D., Columbia University

David C. Willen, Lecturer
B.S., M.S., Polytechnic Institute of New York

Rosalind Yu, Lecturer
B.B.A., Kent State University; M.B.A., St. John's University; M.S. (IS), Polytechnic University of New York

RETIRED FACULTY

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
CONTEMPORARY LIBERAL ARTS CORE CURRICULUM

This core curriculum represents a new vision of liberal education. It is based on the idea that a well-educated liberal arts graduate should be able to understand creativity from the fine arts to technology; and be able to appreciate the poetics of artificial as well as natural languages.

Students majoring in other disciplines are able to take the following courses in this curriculum to satisfy humanities and social science elective requirements:

LA 110 Technology and Society in Historical Perspective
LA 132 Introduction to Behavioral Science
LA 140 Ethics and Technology
LA 141 Materials and Social Issues
LA 142 Machines and Humanity
LA 143 Information, Communications and Society
LA 144 Energy Technology and Social Issues
LA 150 The Making of Connections

Typical Course of Study for the Bachelor of Science Degree in Humanities, Specialized Journalism, or Social Sciences

**Freshman Year**

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Credits</th>
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<tbody>
<tr>
<td>HU</td>
<td>101 Writing and the Humanities I</td>
<td>3</td>
</tr>
<tr>
<td>SS</td>
<td>104*Main Themes in Contemporary World History</td>
<td>4</td>
</tr>
<tr>
<td>LA</td>
<td>110 Technology and Society in Historical Perspective</td>
<td>3</td>
</tr>
<tr>
<td>LA</td>
<td>120 Principles of Mathematics I</td>
<td>4</td>
</tr>
<tr>
<td>LA</td>
<td>125 Introduction to Computers</td>
<td>4</td>
</tr>
<tr>
<td>PE</td>
<td>101 Physical Education I</td>
<td>3</td>
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**Sophomore Year**

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<th>No.</th>
<th>Subject</th>
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<tr>
<td>LA</td>
<td>132 Introduction to Behavioral Science</td>
<td>4</td>
</tr>
<tr>
<td>PE</td>
<td>103 Physical Education III</td>
<td>4</td>
</tr>
<tr>
<td>CS</td>
<td>or EL*</td>
<td>12</td>
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**Junior Year**

<table>
<thead>
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<th>No.</th>
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<tr>
<td>LA</td>
<td>141 Materials and Social Issues</td>
<td>3</td>
</tr>
<tr>
<td>LA</td>
<td>142 Machines and Humanity</td>
<td>3</td>
</tr>
<tr>
<td>CS</td>
<td>or EL*</td>
<td>12</td>
</tr>
<tr>
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</table>

**Senior Year**

<table>
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<th>No.</th>
<th>Subject</th>
<th>Credits</th>
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</thead>
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<tr>
<td>LA</td>
<td>150 The Making of Connections</td>
<td>3</td>
</tr>
<tr>
<td>CS</td>
<td>or EL*</td>
<td>12</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

*CS = Concentrated studies in major; EL = electives
CONTEMPORARY LIBERAL ARTS CORE CURRICULUM

Summary of Requirements

<table>
<thead>
<tr>
<th>Institute requirements (HU 101, HU200*, SS 104*)</th>
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<tbody>
<tr>
<td>Liberal arts core</td>
<td>48</td>
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<tr>
<td>Concentrated studies</td>
<td>33-42</td>
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<tr>
<td>Electives</td>
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<tr>
<td>Humanities</td>
<td>6</td>
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<td>Social Science</td>
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<tr>
<td>Free electives**</td>
<td>15-24</td>
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<tr>
<td>Total credits for graduation</td>
<td>126</td>
</tr>
</tbody>
</table>

*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.
**Students may elect to minor 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).

COURSES

LA 110 Technology and Society in Historical Perspective 3:0:3
An examination of the role of secular and religious ideas 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 Principles of Mathematics I & II each 4:0:4
An introduction to the principles of finite mathematics and calculus. Focus is on the mathematical concepts of the number system, units, integration, probability, statistics, derivatives, and matrices.

LA 125 Introduction to Computers 2:3:3
Introduction to the basic principles of computer and information processing for non-technical students. Survey of operating systems and programming languages. Heavy emphasis on personal computer applications for the liberal arts. Application packages in word processing, database management, spreadsheets, communications, and graphics.

LA 130 Introduction to Physical Science 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 workviews. Topics include: space-time, 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 Introduction to Biological Science 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. Considers the effects of technology on ecology. Laboratory experiments and field trips are used to further elucidate these concepts.

LA 132 Introduction to Behavioral Science 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. Includes issues of professional engineering ethics.

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 and Humanity 3:0:3
An examination of machines in both their technical and human aspects. An analysis of work and power, and the use of machinery to duplicate and extend human dexterity and skill. Discussion of the human aspects includes the relation between machines and different social orders, and humanization vs. dehumanization by machines.

LA 143 Communication and Society 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, science-technology and the imagination, 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.

LA 160 Senior Seminar and Thesis 4:0:4
An individual research project culminating in a substantial paper. Subject to be chosen by student in consultation with a thesis advisor.

FACULTY

William Blesser, Professor and Director of Bioengineering
George Bugliarello, President and Professor of Civil Engineering and Bioengineering
Edward Cassedy, Professor of Electrical Engineering
Carmine D’Antonio, Professor of Metallurgy
Duane DeVries, Associate Professor of English and Acting Head of Humanities & Communications

Frederick Eirich, Distinguished Professor of Polymer Chemistry

Donald Hockney, Professor of Humanities and Communications, of Computer Science.

Burton Lieberman, Associate Professor of Mathematics

Ernest M. Loeb, Professor of Physical Chemistry

Carl Mitcham, Associate Professor of Humanities

CONTEMPORARY LIBERAL ARTS CORE CURRICULUM

Shirley Motzkin, Professor of Biology

Jane Robinett, Assistant Professor of Humanities and Communications

Kurt Salzinger, Professor of Psychology

A. George Schillinger, Associate Professor of Management and Operations Research

Romualdas Sviedrys, Associate Professor of History of Technology
COOPERATIVE EDUCATION PROGRAM

The Cooperative Education (Co-op) 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 students to combine the required number of classroom credits with approximately 20-24 months of work experience. The first and fifth years are spent on campus during the normal September to May academic schedule, while the middle years, including summers, are devoted to alternating periods of training in industry and study on campus.

For graduate students and undergraduate transfer students, the length of the program and sequence of alternation is determined through faculty recommendation.

Students accepted into the program start interviewing with participating Co-op companies during the semester prior to the first scheduled work period. The Cooperative Education Office is responsible for setting up interviews. In most cases, interviews determine whether students are hired as Co-op employees.

Co-op student employees are paid salaries and, in most cases, receive company benefits. Students will be given work directly related to their career goals and levels of academic experience.

The Cooperative Education Program is optional. Completion of the co-op courses is not required for graduation.

Students participating in the program for at least three co-op field experiences receive co-op certificates upon graduation.

ELIGIBILITY

Before being given the initial Co-op work assignment, students 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); (Satisfactory completion of these seminars is required of all freshmen and sophomores before their first work assignment);
- Obtain advisor approval for program participation;
- Obtain departmental approval for program participation.

Graduate students are eligible for participation at any time after scheduling work periods with their faculty adviser.

CO-OP SEMINARS

Co-op pre-employment seminars prepare students for entry into professional environments and are a prerequisite to participation in the work experience sequence.

CP 101 examines methods of discovering fields which are most fulfilling. Topics include techniques of resume writing; interviewing; making contact with prospective employers; planning for advancement; and other issues which help bridge the gap between education and work.

CP 102 assists students in the development of skills and the practice of oral and written communication. Rudiments of technical report writing and public speaking are presented.

CO-OP FIELD EXPERIENCES

Students entering industrial assignments after the freshman year normally complete five field experience courses, CP 201 through CP 401; students entering after the sophomore year might complete only three field experience courses. Types, complexities and challenges of field assignments vary depending upon the students' academic preparation, ability, and interest. The initial field experience (CP 201) usually serves as an introduction to the technical work environment. Students are assigned work under supervisors, who are usually senior staff professionals. As students progress through subsequent field assignments, more complex tasks and duties are added.

COURSES

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP 101</td>
<td>Cooperative Education Seminar I</td>
<td>1:0:NC</td>
</tr>
<tr>
<td></td>
<td>Career Development</td>
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<tr>
<td>CP 102</td>
<td>Cooperative Education Seminar II</td>
<td>1:0:NC</td>
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<tr>
<td></td>
<td>Technical Communication</td>
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<tr>
<td>CP 201</td>
<td>First Co-op Field Assignment</td>
<td>0:6:NC</td>
</tr>
<tr>
<td></td>
<td>Prerequisite: CP 101, CP 102 or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>departmental approval</td>
<td></td>
</tr>
<tr>
<td>CP 202</td>
<td>Second Co-op Field Assignment</td>
<td>0:6:NC</td>
</tr>
<tr>
<td></td>
<td>Prerequisite: CP 201</td>
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</tr>
<tr>
<td>CP 301</td>
<td>Third Co-op Field Assignment</td>
<td>0:6:NC</td>
</tr>
<tr>
<td></td>
<td>Prerequisite: CP 202</td>
<td></td>
</tr>
<tr>
<td>CP 302</td>
<td>Fourth Co-op Field Assignment</td>
<td>0:6:NC</td>
</tr>
</tbody>
</table>
Prerequisite: CP 301

CP 401 Fifth Co-op Field Assignment 0:B:NC
Prerequisite: CP 302

Grades of (S) "satisfactory" or (U) "unsatisfactory" are recorded upon completion of each course. Courses will not be computed in the grade point average (G.P.A.). These grades are based upon final reports and work evaluations written by students and evaluations submitted by supervisors.

Nominal registration fees are charged for each field assignment.

COORDINATORS

Ernest B. Racz, Associate Provost and Director of Career Services and Cooperative Education

Beatrice Hackenerg, Assistant Director, Long Island Campus.
B.S., SUNY-Empire State College; M.S., Polytechnic Institute of N.Y.

Kathleen L. Kennedy, Assistant Director, Career Services and Cooperative Education.
B.S. Univ. of Dayton; M.S. Wright State University

Dina Yershova, Coordinator of Job Development
ELECTRICAL ENGINEERING

The Department of Electrical Engineering and Computer Science administers a variety of degree programs summarized in the table below. From its beginnings in the 1880's the department has enjoyed national and international reputation based on the accomplishments of its alumni, on the research achievements of students and faculty, and on the textbooks written by faculty and alumni. This reputation has been confirmed periodically by surveys of members of the profession; the latest, the 1985 Gourman Report shows Polytechnic EE programs as best in the New York City area and high nationally. 12th for BS and 13th for MS; and the most recent American Society for Engineering Education list has the PhD (EE) 10th nationally, out of over 200 Electrical Engineering degree programs in the United States.

This section of the catalog describes the programs and courses in electrical engineering. 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 the electrical engineering section. Programs and courses in computer science, and the graduate program in information systems, are described in the computer science section of the catalog. The departmental faculty also participates in the graduate programs in energy, imaging sciences, and telecommunications management, described elsewhere in the catalog.

<table>
<thead>
<tr>
<th>Degree Programs Administered by the Department of Electrical Engineering and Computer Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNDERGRADUATE</td>
</tr>
<tr>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Bachelor of Science</td>
</tr>
<tr>
<td>Electrical Engineering Option</td>
</tr>
<tr>
<td>Computer Engineering Option</td>
</tr>
<tr>
<td>Computer Science</td>
</tr>
<tr>
<td>Bachelor of Science</td>
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<tr>
<td>GRADUATE</td>
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<tr>
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<td>Master of Science</td>
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<tr>
<td>Electrical Engineer</td>
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<tr>
<td>Doctor of Philosophy</td>
</tr>
<tr>
<td>System Engineering</td>
</tr>
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<td>Master of Science</td>
</tr>
<tr>
<td>System Engineer</td>
</tr>
<tr>
<td>Doctor of Philosophy</td>
</tr>
<tr>
<td>Electrophysics</td>
</tr>
<tr>
<td>Master of Science</td>
</tr>
<tr>
<td>Doctor of Philosophy</td>
</tr>
<tr>
<td>Computer Science</td>
</tr>
<tr>
<td>Master of Science</td>
</tr>
<tr>
<td>Doctor of Philosophy</td>
</tr>
<tr>
<td>Information Systems</td>
</tr>
<tr>
<td>Master of Science</td>
</tr>
</tbody>
</table>

THE ELECTRICAL ENGINEERING PROFESSION

Electrical engineering is a rapidly growing profession which has evolved from its early beginnings in electric power generation and distribution through the development of radio to television and computers. More recently, it 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 undergraduate and graduate programs in electrical engineering are designed primarily to develop talents in these areas, 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. Principal areas of teaching and research are micro-electronic devices and systems; computer engineering and computer science; telecommunications; signal and image processing; electro-optics and electro-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 students broad-based preparation for a career in electrical engineering in any of its specializations, and readies them for immediate employment in industry, business, and government, or for further graduate education. The program (both campuses, both options) is 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

There are two programs with somewhat different course requirements, the electrical engineering option and the computer engineering option; the two curriculum tables are shown below. Both options are accredited by the Accreditation Board for Engineering and Technology (ABET) as electrical engineering degrees. The two options differ in five courses, out of the total 36 required courses:

Electrical engineering option: EE 162, EE 167, EE 180, EE 196, EE 197
Computer engineering option: CS 203, CS 204, CS 205, CS 298, CS 299

Changes from one option to the other can be made at any time and do not require departmental approval. Depending on their initial choice of option, entering freshman register for slightly different courses: electrical engineering option students take SS 104 in the first semester and CS 112 in the second semester, whereas students in the computer engineering option start with CS 112 and continue with CS 204 in the second semester. Initially
undecided students should start with CS 112 because it is somewhat simpler to switch from the computer engineering option to the electrical engineering option than the other way around.

The freshman year courses in the BS (EE) computer engineering option and in the BS (CS) degree program are identical, but thereafter the curricula diverge. See page 86 for details of the computer science degree program.

Curriculum of Study for the Bachelor of Science Degree in Electrical Engineering (for Freshmen entering in 1988)

ELECTRICAL ENGINEERING OPTION

Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
</tr>
<tr>
<td></td>
<td>Calculus I&quot;</td>
</tr>
<tr>
<td>MA 101</td>
<td></td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab I</td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing &amp; the Humanities I</td>
</tr>
<tr>
<td>SS 104</td>
<td>Main Themes in Contemporary World History&quot;</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education&quot;</td>
</tr>
</tbody>
</table>

Second Semester

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subject</td>
<td>Cl.</td>
</tr>
<tr>
<td>CS 112</td>
<td>Programming in Pascal</td>
<td>3</td>
</tr>
<tr>
<td>MA 102</td>
<td>Calculus II&quot;</td>
<td>4</td>
</tr>
<tr>
<td>PH 102</td>
<td>Introductory Physics II</td>
<td>2 1/2</td>
</tr>
<tr>
<td>CM 102</td>
<td>General Chemistry II</td>
<td>2 1/2</td>
</tr>
<tr>
<td>CM 112</td>
<td>General Chemistry Lab II</td>
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</tr>
<tr>
<td>HU 200</td>
<td>Writing &amp; the Humanities II&quot;</td>
<td>3</td>
</tr>
<tr>
<td>PE 102</td>
<td>Physical Education&quot;</td>
<td>0</td>
</tr>
</tbody>
</table>

Sophomore Year

| EE 101 | Elec. Circuits I | 3 | 0 | 3 |
| EE 193 | Soph. EE Lab. I | 1 1/2 | 1 1/2 | 1 |
| MA 104 | Appl. Diff. Equations" | 3 | 0 | 3 |
| PH 103 | Introductory Physics III | 2 1/2 | 1 1/2 | 3 |
| HU 101 | Writing & the Humanities I | 6 | 0 | 6 |
| SS 104 | Main Themes in Contemporary World History" | 0 | 2 | 0 |
| PE 103 | Physical Education" | 16 |

Junior Year

| EE 102 | Elec. Circuits II | 3 | 0 | 3 |
| EE 194 | Soph. EE Lab. II | 1 1/2 | 1 1/2 | 1 |
| MA 103 | Calculus III" | 3 | 0 | 3 |
| PH 230 | Atom. & Nucl. Physics | 2 | 0 | 2 |
| AM 115 | Eng. Mechanics" | 4 | 0 | 4 |
| HU 201 | Writing & the Humanities II" | 3 | 0 | 3 |
| PE 104 | Physical Education" | 16 |

Senior Year

| EE 104 | Feedback Systems | 3 | 0 | 3 |
| EE 112 | Solid State Circ. II | 3 | 0 | 3 |
| EE 162 | Electromagnetic Fields | 4 | 0 | 4 |
| EE 196 | Jr. EE Lab. II | 1 | 3 | 2 |
| MA 223 | Probability"" | 3 | 0 | 3 |
| HU 202 | Writing & the Humanities II" | 3 | 0 | 3 |

CS 236 | Switching & Dig. Sys."" | 3 | 0 | 3 |

H Courses: 19

EE 113 | Solid State Circ. III | 3 | 0 | 3 |
| EE 140 | Communications"" | 3 | 0 | 3 |
| EE 167 | Quantum Electronics"" | 3 | 0 | 3 |
| EE 168 | Elec. Machinery I"" | 3 | 0 | 3 |
| EE 197 | Sr. EE Lab. I | 1 | 3 | 2 |
| Technical elective"" | 3 | 0 | 3 |

17

Total credits required for graduation: 136
### 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>
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<td>No.</td>
<td>Subject</td>
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<tr>
<td>---</td>
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<td>---</td>
<td>---</td>
</tr>
<tr>
<td>CS</td>
<td>112 Programming in Pascal</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MA</td>
<td>101 Calculus I</td>
<td>4</td>
<td>0</td>
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<tr>
<td>PH</td>
<td>101 Introductory Physics I</td>
<td>3</td>
<td>0</td>
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<tr>
<td>CM</td>
<td>101 General Chemistry I</td>
<td>2 1/2</td>
<td>0</td>
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<tr>
<td>CM</td>
<td>111 Gen. Chem. Lab. I</td>
<td>0</td>
<td>1 1/2</td>
</tr>
<tr>
<td>HU</td>
<td>101 Writing &amp; the Humanities I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PE</td>
<td>101 Physical Education</td>
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### Sophomore Year

<table>
<thead>
<tr>
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<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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</thead>
<tbody>
<tr>
<td>EE</td>
<td>101 Elect. Circuits I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>EE</td>
<td>102 Elect. Circuits II</td>
<td>3</td>
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<tr>
<td>EE</td>
<td>103 Soph. EE Lab. I</td>
<td>1 1/2</td>
<td>1 1/2</td>
<td>1</td>
<td>EE</td>
<td>104 Soph. EE Lab. II</td>
<td>1 1/2</td>
<td>1 1/2</td>
<td>1</td>
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<tr>
<td>CS</td>
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<td>103 Calculus III</td>
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<td>MA</td>
<td>104 Appl. Diff. Equations</td>
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<td>0</td>
<td>3</td>
<td>PH</td>
<td>230 Atom. &amp; Nucl. Physics</td>
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<tr>
<td>PH</td>
<td>103 Introductory Physics III</td>
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<td>AM</td>
<td>115 Eng. Mechanics</td>
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<td>200 Writing &amp; the Humanities II</td>
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<tr>
<td>PE</td>
<td>103 Physical Education</td>
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<td>PE</td>
<td>104 Physical Education</td>
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### Junior Year

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<th>No.</th>
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<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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</thead>
<tbody>
<tr>
<td>EE</td>
<td>105 Signals &amp; Transforms</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>EE</td>
<td>104 Feedback Systems</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<tr>
<td>EE</td>
<td>111 Solid State Circ. I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>EE</td>
<td>112 Solid State Circ. II</td>
<td>3</td>
<td>0</td>
<td>3</td>
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<tr>
<td>EE</td>
<td>195 Jr. EE Lab. I</td>
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<td>3</td>
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<td>EE</td>
<td>188 Computer Lab. I</td>
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<td>3</td>
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<tr>
<td>CS</td>
<td>203 Advanced Machine Lang.</td>
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<td>3</td>
<td>CS</td>
<td>237 Computer Architecture</td>
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<tr>
<td>CS</td>
<td>236 Switching &amp; Dig. Sys.</td>
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<td>0</td>
<td>3</td>
<td>MA</td>
<td>223 Probability</td>
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<td>3</td>
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### Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tr>
<td>EE</td>
<td>113 Solid State Circ. III</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>EE</td>
<td>199 Sr. EE Lab. III</td>
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<td>EE</td>
<td>140 Communications</td>
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<td>EE</td>
<td>161 Lines and Waves</td>
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<td>CS</td>
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<td></td>
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<td>0</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| | | | | | Total credits required for graduation: 136 |

*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 102. A few may be exempted from HU101 and placed directly in HU 200, others may first be required to take the non-credit HU 005 or HU 009."

*Full-time students take four semesters of Physical Education; the same course number may be repeated. Polytechnic ROTC courses MS 101, 102, 201, and 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. Waivers are prorated when part-time attendance or transfer 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 140-141 may be substituted for HU 200 plus SS 104."

*Take HU, IS, LA, ML, or SS lettered courses in consultation with the adviser."

*As part of the requirements in the humanities and social sciences for engineering undergraduates, students should select an area of concentration (such as literature, communications, the arts, or philosophy and comptitative religions in the department of humanities and communication, or economics, history, anthropology, or psychology in the department of social sciences) and to elect a number of courses in this concentration in consultation with their advisor. A modern language may be chosen as a suitable concentration but students without prior knowledge of the language must plan to devote at least 12 credit hours to it."

At least 18 of the credits students select in the humanities and social sciences must meet the requirements of the Accreditation Board for Engineering and Technology (ABET). These credits may not include skills-oriented courses such as technical writing, public speaking, or English as a second language. Courses in literature, foreign languages, history, economics, and others are acceptable. Students should consult their advisors to ensure that these criteria are met."

*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."

*Students may start their electives and defer MA 223 and EE 140 by one semester."

*Technical electives are chosen from a list of approved courses, departmental and out-of-department, published and updated each year. A free elective can be any course which is not duplication of material studied under another course number. See footnote 26 for restriction on project courses."

*ROTC cadets may use a maximum of six credits of junior/senior level ROTC courses to replace three credits of free electives and three credits of technical electives. Eligible courses are MS 301, 303, 401, 403."

*EE 199 may be replaced by EE 396 or by EE 397. Not more than six credits of projects courses may be offered toward the BS (EE) degree.
ELECTIVE CONCENTRATIONS

There are 10 elective courses, in both options, of which five must be in the humanities and social sciences subjects, and the balance in the physical sciences, mathematics, or engineering. Most students take electives to sample fields not covered in required courses, or to take an advanced course in a subject already studied. Other students with firm professional goals prefer to concentrate their elective courses in a chosen area. Students who plan to take a sequence of related electives can defer one or two of the required junior year courses to a later semester. One popular concentration is to take courses in the other option as electives. Other elective concentrations which have found acceptance are as follows:

Electrophysics Concentration — for students whose interests lie in electromagnetics and solid-state devices. Courses offered prepare students to work in such areas as antennas, microwave components, lasers, optics and integrated circuits.

Power Engineering Concentration — for students whose interests lie in the area of power and energy. Most of these specialized courses are available only on the Brooklyn campus.

Bioengineering Concentration — for students who wish to combine a career in the life sciences with electrical or computer engineering. These specialized courses are available only on the Brooklyn campus.

Transfer credits for courses taken 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 credits. 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 of their first semester at Polytechnic.

HONORS PROGRAM

Full-time students in electrical engineering can be admitted into BS/MS honor a program which leads to simultaneous award of the bachelor’s degree (electrical engineering) and master’s degree (electrical engineering, electrophysics, computer science, or system engineering). Depending on the student’s preparation and objectives, completion of the two degrees may come as early as the end of the fourth year of study. Admission into the program is normally made at the start of the freshman year, however, special programs may be worked out for other students individually with the departmental honors advisor. Acceleration can be achieved through advanced placement, through credit by examination, and through summer coursework or research participation. The program is intended for students with outstanding academic records.

SENIOR HONOR STUDENTS

A full-time day student whose performance during the first three years is outstanding will be named as a senior Honor Student and is permitted to replace some of the required senior technical courses with other courses, usually more advanced, which are directed toward the student’s professional goals.

Graduate courses (non-daggered) may be taken as electives by senior students whose junior year grade-point averages in technical courses exceed 2.7. Daggered electrical engineering graduate courses may be taken as senior electives by any undergraduate.

DEPARTMENTAL STANDARDS AND PROBATION

To earn a B.S. degree in electrical engineering, students must have a minimum C average (2.00 grade-point...
ELECTRICAL ENGINEERING

average) in the major, consisting of the courses in electrical engineering and computer science plus other technical subjects. This requirement for a minimum technical average is above and beyond the Polytechnic B.S. degree requirements for a minimum 2.00 grade-point average overall. Students below average, or deficient in a subject will be placed on departmental probation as a warning that they are not acceptably progressing towards the degree. Continued inability to meet the conditions of the probation may lead to academic disqualification from the B.S. (E.E.) degree program.

Probation action may be occasioned by a semester or cumulative technical average of less than 2.00; grades lower than C in important courses, particularly EE 101-102; failure to adhere to course prerequisites; or excessive or unauthorized course withdrawals. Students on probation may be required to reduce their course load or restrict their extracurricular activities; they may be required to postpone an advanced course, or to undertake a remedial course program, or they may be made to repeat courses passed with a grade less than C. Almost without exception, students earning a D+, D, or I in EE 101 or EE 102 will be asked to repeat the course; the same holds for CS 112 and CS 204 for students in the computer engineering option. Likewise, a student with less than a C semester average or less than a C average in courses of a closely related sequence, may be asked to repeat courses in which grades were D+, D, or I.

When a course is repeated, the second grade is required to be no lower than C. Failure to achieve this leads to disqualification from the program. Permission to try a course more than twice is granted only under exceptional conditions. Exclusion of the first grade of a repeated course in the computation of the technical grade-point average applies for a maximum of four such courses. If additional courses are repeated, all grades count, including the first.

Students on probation are usually permitted to preregister for the next semester, but are obliged to consult their advisers after their grades are posted, before the start of classes. Students who undertake courses in violation of their probation face deregistration and possible disqualification.

INFORMATION

The Undergraduate Student Manual, issued to all students contains further details on honors, probation, approved electives, projects, elective concentrations, and other matters of interest. Curriculum and prerequisite changes, new courses, special sections, and other last minute announcements are posted on the bulletin boards outside the electrical engineering undergraduate office in Brooklyn and of the departmental office on the Long island campus. All students are responsible for keeping informed.

GRADUATE STUDIES

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 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 — System 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, and 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 enginee, 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 deal 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 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 student who also desires to obtain a Polytechnic B.S. degree in electrical engineering must do so first, before beginning studies 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 count toward the master's degree. Students without an electrical engineering B.S. degree may also want to consider the departmental master's degree programs in electrophysics and in systems 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 requirement for the M.S. in electrical engineering degree, the student must complete a total of 36 units of courses, as described below. An overall grade average of B in all graduate courses is required by the University. 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

2. Two one-year sequences which may include courses in group (1). Both sequences must be in EL or CS courses and at least one must be an EL sequence.
   6-12

3. Approved electives, which may include a thesis (9 units) and one reading course (3 units maximum).
   21-15

At least 18 of the 36 units offered for the M.S. degree in electrical engineering must be in EL prefixed courses, and at least 24 units must be in EL or CS 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 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 after 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 taken as electives.

Theses: Exceptional students 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. 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 Polytechnic 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 credits may be allowed in accord with Polytechnic 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 foregoing tabulation:

1. Core courses: EL 531, EL 610 or EL 611, EL 671.
2. One-Year sequences: EL 661, EL 662, EL 665, EL 666.
3. Electives:
   (a) ES 927-928 is required.
   (b) 9 units from a list of specified courses.
THE ENGINEER DEGREE

The engineer in electrical engineering degree is offered in recognition of the need of systems 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 departmental 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 other departments. The committee is appointed 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 which demonstrates mature design, engineering economics, trade-offs, etc., for which the student receives 6-12 units
3. Approved electives 30-24 units

The engineer project may be suggested by either the student or the guidance committee and is officially approved on the student's submission of an acceptable written proposal which details the problem, background and approach, gives the budget for estimated project expenses and states the desired number of units (6, 9 or 12) to be earned. Upon 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 requirements 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 goal towards the doctorate. The degree of Ph.D. is awarded after completing the program of studies and research described below and preparation and defense of a dissertation representing an original and significant contribution worthy of publication in a recognized scientific or engineering journal.

Admission to Programs — Entrance into the doctoral program of study and research is contingent on the candidate's passing the departmental qualifying examinations 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 examinations within the calendar year.

Students entering the doctoral program at the baccalaureate level must meet the entrance requirement listed above 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 degree 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 broad 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 systems 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 — Upon passing the qualifying examination, the graduate student must find a faculty member in the student's area of major interest who will become the thesis adviser. In consultation with the thesis adviser, the student suggests an adviser for a minor outside of electrical engineering, electrophysics, or systems engineering, and a guidance committee of three or four faculty members, with the thesis adviser usually acting as chairman. At least one other guidance committee member must be in the student's area of major research interest; this member may be from outside of the Polytechnic. The
Minor adviser may, but need not, be a member of the guidance committee. The student must submit the names of these guidance committee members to the EE Graduate Committee for approval.

The thesis adviser approves the program of study in the student’s major, and the minor adviser approves the program of courses in the minor. When the requirements for minor or major are completed, the student should have the appropriate advisor certify this in writing to the Office of Graduate Affairs, with copies to the EE Graduate Office.

The guidance committee conducts the area examination and thesis defense, and approves the final thesis.

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 a minor area outside of seminars is expected when they are offered in the student’s study in depth of the most advanced. 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 thesis adviser. The major program should constitute a coherent study in depth of the most advanced knowledge in the student’s 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 consists of a presentation or review of the general background in the problem area of the student’s dissertation. The purpose of the examination is to demonstrate that the student understands the fundamental prior research in the field of the thesis work. The examination should be taken early in the Ph.D. program, after no more than 12 units of dissertation have been taken, and should not be a review of partial thesis results. The examination may be in the form of an open seminar attended by other interested faculty and students. The guidance committee evaluates the student’s performance and determines whether the depth of knowledge and understanding necessary to carry out research in the chosen area has been demonstrated.

Postponement of the area examination beyond registration for 12 units of thesis requires the approval of the EE Graduate Committee.

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 Research and Graduate Studies of the candidate’s readiness so that the examination date may be scheduled. The student is advised to consult the Office of Research and Graduate Studies regarding submission of the final manuscript, reproduction and binding.

UNDERGRADUATE COURSES

Students are advised to consult the departmental Undergraduate Student Manual and the Schedule of Classes for changes of courses, course content and prerequisites in effect after the publication of this catalog.

General prerequisites: students may not register for any junior- or senior-level courses until all freshman requirements are completed. Knowledge of computer programming at the level of CS 112 is assumed in all EE courses.

BASIC COURSES

EE 101 Electric Circuits 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, RLC and RLC circuits. Prerequisites: MA 101-2, PH 101-2, and CS 112 (all with grade C or better). Corequisites: MA 104 and PH 103.

EE 102 Electric Circuits II 3:0:3
Continuation of EE 101. Sinusoidal steady-state response. Phasors. Theorems, including maximum power. Root-mean-square values and average power. Complex frequency domain; Resonance. Complex Fourier series. Three-phase systems. Prerequisites: EE 101 (grade C or better), PH 103, and MA 104.

EE 103 Signals & Transforms 4:0:4
Analog and digital systems. Integro-differential equations and recursion equations. Solutions by Laplace and z-Transforms. Transfer functions and synthesis. Discrete and continuous convolution. Frequency response, discrete Fourier series and Fourier integral. Prerequisites: EE 102 (grade C or better) and MA 104.

CONTROL AND INSTRUMENTATION

EE 104 Feedback System Principles 3:0:3

EE 107 Control System Design 3:0:3
Topics on the design of linear feedback control systems, selected from the following: lag-lead compensators; pole-placement controllers; state-variable feedback and observers; linear quadratic optimal control; stochastic systems; sampled-data and computer-controlled systems; and phase-plane and describing-function techniques for non-linear systems. (See departmental bulletin board for detailed descriptions of each offering and of any additional prerequisites). Prerequisite: EE 104.

ELECTRONIC CIRCUIT ANALYSIS AND DESIGN

EE 111 Solid-State Devices and Circuits I 3:0:3
Introduction to semiconductor physics, diode and bipolar transistor devices and models. Large- and small-signal operation of transistors, inverters, emitter followers, differential amplifiers. Transient response of transistors and transistor amplifier circuits. Prerequisites: PH 230 and EE 102 (grade C or better).
ELECTRICAL ENGINEERING

EE 112 Solid-State Devices and Circuits II 3:0:3
Junction and MOSFET transistor physics and models. Single-device circuits and MOSFET inverter pairs. Low- and high-frequency response of single-stage amplifiers. Transient response, integrated circuit operational amplifier design, analysis and applications. Bipolar and MOSFET logic families. Prerequisite: EE 111.

EE 113 Solid-State Devices and Circuit 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 115 Advanced Electronics 3:0:3
Special topics in electronic circuits and instrumentation, second-order modelling. Advanced transistor and integrated circuit design, active and passive memories. Application of bistable devices. Non-linear devices including topics such as digital circuits, blocking oscillators, ferrero-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, sine-wave oscillators, mixers, AM modulators and demodulators, FM modulators and demodulators. Prerequisite: EE 115.

EE 119 Semiconductor Technology* 3:0:3
Principal techniques involved in processing and fabrication of semiconductor devices and integrated circuits including material preparation, junction formation, circuit integration and packaging. Prerequisite: EE 111 or MT 110. Also listed under MT 375.

EL 545-546 Microwave Integrated and Semiconductor Circuits III* See graduate course listings.

COMMUNICATIONS AND INFORMATION TRANSMISSION

EE 140 Principles of Communication Systems 3:0:3
Principles and techniques for modern communications systems. Analog and digital signals, sampling, quantization, signal representation, encoding and digital modulation, pulse code modulation, time and frequency multiplexing. Noise in communication systems. Prerequisites: EE 103 and MA 223.

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 140.

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 (grade C or better). PH 103, MA 103 and MA 104.

EE 162 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 167 Quantum and Solid State Electronics 3:0:3

EE 199 Semiconductor Laboratory Special section of course listed under Senior Electrical Engineering Laboratory II. Fabrication of PMOS transistors starting with a blank silicon wafer; mask generation, lithography, oxidation, diffusion, metallization, and encapsulation. Test and analysis of completed packages. Available on Long Island Campus. Lab fee required. Prerequisite: EE 119.

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 180 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 181 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 180.

EE 183 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 (grade C or better).

EE 199 Electrical Machinery Laboratory Special section of course listed under Senior Electrical Engineering Laboratory II. Experiments on transformers, DC and AC machines, and AC generators. Available on Brooklyn Campus. Lab fee required. Prerequisite: EE 180.

EL 564† Electromechanical Power Conversion* See graduate course listings.

EL 568-569† Electric Drives I, II* See graduate course listings.
EL 58† Introduction to Plasma Engineering
See graduate course listings.

**ELECTRICAL ENGINEERING LABORATORY**

Students enrolled in electrical engineering laboratory courses are charged a laboratory fee which includes the cost of a laboratory kit consisting of electronic parts and components. Transfer students who enroll in junior and senior level laboratory courses may be required to purchase components of preceding courses for which they have transfer credits.

EE 189 Computer Laboratory II

An introduction to the use of small computers as system 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. (Last offered fall, 1986.) Prerequisites: EE 188 and CS 237. Also listed under CS 299.

EE 193 Sophomore Electrical Engineering Laboratory I

Introduction to measurement. Lab fee required. Co/Prerequisite: EE 101.

EE 194 Sophomore Electrical Engineering Laboratory II

Electrical circuits laboratory. Lab fee required. Co/Prerequisite: EE 101 and EE 193. Co/Prerequisite: EE 102.

EE 195 Junior Electrical Engineering Laboratory I

Circuits and electronics laboratory. Lab fee required. Prerequisites: EE 194, EE 102. Co/Prerequisite: EE 111.

EE 196 Junior Electrical Engineering Laboratory II

Experiments selected from various areas of electrical engineering. Lab fee required. Prerequisite: EE 195 and Co/Prerequisites: EE 162, EE 104 and EE 112.

EE 197 Senior Electrical Engineering Laboratory I

Experiments selected from various areas of electrical engineering. Lab fee required. Prerequisites: EE 196, EE 112, and EE 161. Co/Prerequisite: EE 113.

EE 199 Senior Electrical Engineering Laboratory II

Experiments selected from various areas of electrical engineering. Special sections in electrical machinery, semiconductor technology, etc., may be offered. Lab fee required. Prerequisite: EE 113 and Co/Prerequisite: CS 237. (Alternative prerequisites are specified for special sections.)

**INTERDEPARTMENTAL COURSES**

EE 370 Principles of Electrical Engineering

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: MA 102, PH 102. Co/Prerequisite: MA 104.

EE 374 Instrumentation Laboratory

Experiments designed to supplement EE 370. (Cannot be used to satisfy any electrical engineering degree requirements.) Lab fee required. Prerequisite: EE 370.

**ELECTRICAL ENGINEERING**

EE 377 Introduction To Electronics

Circuit principles, Kirchhoff's laws, single-energy circuits. The PN junction, diodes, junction transistors, field-effect transistors. Survey of integrated circuit technology, TTL concepts, logic gates, flip-flops, memories, and applications. Linear amplifiers, operational amplifiers and applications. Introduction to electronic laboratory instruments and measurements. (Cannot be used to satisfy any electrical engineering degree requirements.) Lab fee required. Prerequisite: MA 102 and PH 102. Co/Prerequisite: MA 104.

**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

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 adviser. 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

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 departmental 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 statements of problem, choice of methods 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

Solution of electrical engineering problem or detailed study of advanced area of electrical engineering under supervision of adviser. 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 area. The first digit represents the level:

5 — senior/graduated level
6 — first-year graduate level
7, 8 — advanced courses
9 — miscellaneous courses
ELECTRICAL ENGINEERING

Courses in selected topics bearing the same numbers may be repeated for credit provided the topics are different, subject to adviser’s approval.

LINEAR SYSTEMS AND NETWORKS

EL 510 Linear Systems 2 ½:0:3
Basic system concepts. Equations describing continuous and discrete-time linear systems. Response representation and calculation by digital and analog computer. Time domain analysis, state variables, transition matrix, delta and impulse response. Transform methods. Time-variable systems. Prerequisite: Graduate status and EE 103.

EL 611 Signals, Systems and Transforms 2 ½:0:3
Continuous and discrete linear systems, system function, Fourier transforms, periodic functions, Z-transforms, discrete Fourier series, fast Fourier transforms. Analog and digital filters, finite order system functions. Digital processing of analog signals. Sampling theorems. Prerequisite: Graduate status and EE 103.

EL 613 Applied Matrix Theory 2 ½:0:3
In-depth introduction to theory and application of linear operators and matrices in finite-dimensional vector space. Invariant subspaces, elementary divisors, canonic forms and minimax theorems for eigenvalues of hermitian pencils. Prerequisites: Graduate status and MA 103, MA 104. Also listed under MA 837.

EL 615 Network Theory of Lumped and Distributed Structures* 2 ½:0:3
Network principles derived from physical constraints are emphasized. Immittance and scattering formalisms, general energy and reciprocity theorems, properties of distributed parameter and nonreciprocal networks, broadband theory and the synthesis of transmission line broadband quarter-wave transformers. Prerequisite: Graduate status.

EL 617 System Reliability* 2 ½:0:3
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 failures, dependent failures. Prerequisite: EL 531 or MA 561 or equivalent. Also listed under IE 685.

EL 618 Component Reliability* 2 ½:0:3
Failure models for industrial components: exponential, Weibull, lognormal, gamma, Gumbel and other distributions. Failures and hazard rates, graphical probability plots and maximum-likelihood parameter estimation and testing. Sampling plans based on life tests and accelerated life tests. Sequential and parallel analysis on component reliability. Prerequisite: EL 531 or MA 561 or equivalent. Also listed under IE 686.

EL 711 Advanced Signals and Systems* 2 ½:0:3

EL 713 Digital Signal Processing* 2 ½:0:3

EL 911-912 Selected Topics in Systems and Networks I, II* each 2 ½:0:3
Selected topics of current interest in systems and networks. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

CONTROL SYSTEMS

EL 621 Feedback Control I 2 ½:0:3

EL 622 Feedback Control II 2 ½:0:3

EL 720 System Theory and Feedback 2 ½:0:3
Design of multivariable feedback systems in the complex s-plane. Stability of interconnected systems from component transfer matrices. The class of stabilizing controllers: Optimal and suboptimal design considerations for two-degree-of-freedom systems. Prerequisites: EL 610 and EL 613.

EL 723 System Optimization Methods 2 ½:0:3
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, and linear, nonlinear and dynamic programming. Iterative methods. Examples and applications. Prerequisite: EL 610 or EL 613.

EL 821 Analysis of Stochastic Systems* 2 ½:0:3

EL 823 Optimal Control Theory* 2 ½:0:3
Optimal control problem for deterministic systems with various constraints. Solution for both continuous and discrete-time systems using the maximum principle and dynamic programming. Hamilton-Jacobi theory as applied to the synthesis problem. Prerequisite: EL 723. Also listed under MA 844.

EL 921-922 Selected Topics in Control Engineering I, II* each 2 ½:0:3
Topics of current interest in feedback and control system engineers. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

INFORMATION SCIENCE

EL 531 Probability 2 ½:0:3
EL 631 Engineering Applications of Stochastic Processes 2½:0:3
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 633 Detection and Estimation Theory 2½:0:3

EL 635 Principles of Communication Networks 2½:0:3

EL 733 Advanced Signal Processing* 2½:0:3

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.

ELECTRONIC DEVICES, CIRCUITS AND SYSTEMS

EL 540 Solid-State Devices and Circuits* 2½:0:3

EL 545† Microwave Integrated and Semiconductor Circuits I 2½:0:3
Electric and magnetic properties of materials which are used in integrated and semiconductor circuits. Common guiding structures such as microstrip with application to coupled transmission lines. Passive microwave PN, PIN and Schottky diodes. Active Gunn and IMPATT diodes. System sensitivity characterization. (Tangential sensitivity and noise figure.) Prerequisites: EE 162 and EE 112.

EL 546† Microwave Integrated and Semiconductor Circuits II* 2½:0:3
Non-reciprocal devices. Microwave bipolar and GaAs FET devices. Transistor amplifier design and transformers. Various types of microwave oscillators. Monolithic GaAs circuits. Enrollment limited. Prerequisite: EL 545 and approval of the microwave program adviser.

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 un tuned power amplifiers. Sweep circuits and synchronization. Prerequisite: EL 641.

EL 645 Integrated Circuit (VLSI) System Design 2½:0:3
Overview of digital electronic circuit functions on a single silicon chip. Systematic approach to design from circuit function to basic layout, subsystem layout, and mask layout using techniques based on computer-aided design. Computer testing of logic functions and simulation of circuit functions. Prerequisites: Graduate status, CS 237 and EE 113.

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ELECTRICAL ENGINEERING

EL 646  Integrated Circuit (VLSI) Fabrication Techniques  2 ½:0:3
Study of process technology used to produce integrated circuits with emphasis on silicon technology: bipolar, MOS, and VLSI processes. Definition of process requirements in terms of circuit structure, i.e., concentration profiles and topographical layout as defined by previously determined mask set. Analysis of the steps from crystal growth through diffusion, ion implantation, oxidation, photolithography, metallization, interconnection, and packaging to final tests. Study of impact and process on design rules. Prerequisites: Graduate status and EE 112. Also listed under MT 709.

EL 647  Power Electronics  2 ½:0:3
Principles of thyristor devices, dynamic characteristics of DC choppers, dependence of turnoff circuits on process requirements in terms of circuit devices and systems. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

EL 941-942  Selected Topics in Electronics I, II*  each 2 ½:0:3
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 2 ½:0:3
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, 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  2 ½:0:3
Crystal structures and dynamics, lattice vibrations, the phonon, thermal conductivity of solids. Energy-band theories, Brillouin zones, conductors, semiconductors, insulators, semiconductor junctions, junction devices, light-emitting diodes, detectors for visible and infrared. Prerequisite: EE 167.

EL 851  Statistical Mechanics I  2 ½:0:3

EL 852  Statistical Mechanics II  2 ½:0:3
Stochastic models, grand-canonical ensembles and principles of classical statistical mechanics. Condensation phenomena. Treatment of fluctuation and transport phenomena. Density matrix formalism of quantum statistical mechanics. Discussion of many-body problems. Prerequisite: EL 651 or PH 663. Also listed under PH 684

EL 653-654  Quantum Electronics I, II  each 2 ½:0:3

EL 655-656  Quantum Mechanics I, II  each 2 ½:0:3
Quantum mechanics with applications to atomic systems. The use of Schrodinger's equations. Angular momentum and spin. Problems and approximation methods. Semi-classical theory of field-matter interaction. EL 655 prerequisite: graduate status. EL 656 prerequisite: EL 655. Also listed under PH 667-668

EL 658  Fiber Optic Communications*  2 ½:0:3
Preview of fiber optic communications, optical fibers, light sources, detectors, modulation techniques. Transmitter, receiver and repeater technology. System applications. Integrated optics. Prerequisite: graduate status.

EL 950  Laboratory in Electronic Materials and Electro-Optics*  0:5:3
Selected experiments in electrical properties of materials. Physical properties of semiconductors, Hall effect measurements, photoelectricity, superconductivity, magnetoresistance, 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 ½:0:3
Topics of current interest dealing with interaction of matter with electromagnetic fields. (See department mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

POWER ENGINEERING

EL 564†  Electromechanical Power Conversion*  2 ½:0:3
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 588†  Electric Drives I: Characteristics and Controls  2 ½:0:3
Transient conditions in electric drives. Load torque, 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 quadrant operation of dc and ac drives with static converter supply. Worked examples effectively illustrate the application of the mathematical derivations. Prerequisite: EE 180.
**FIELDS AND WAVES**

**EL 571-572 Engineering Electromagnetics I, II**

Electrical engineering applications of electromagnetics. A device-oriented course for graduate and advanced undergraduate students. Topics include: hollow conducting waveguides, dielectric guides, two-wire, coaxial and strip transmission lines; linear antennas, arrays, horns and dish antennas. Waveguide components: attenuators, phase shifters, waveguide-coaxial transitions, etc. Electromechanical transducers: loud speakers, microphones, relays. EL 571 prerequisite: EE 162. EL 572 prerequisite: EL 571.

**EL 573 Electromagnetics: Fields and Materials**

Basic concepts of electric and magnetic fields, their sources and their propagation via waves are treated. Emphasis is on understanding electromagnetic wave phenomena (interference, refraction, reflection, etc.) and their engineering applications over the entire electromagnetic spectrum. Prerequisite: graduate status and EE 162.

**EL 574 Electrodynamics: Wave Propagation and Guidance**

Course for students requiring understanding of electromagnetic fields from an 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 571.

**EL 575 Electromagnetics: Field and Wave**

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. EL 571 or PH 623. Also listed under PH 624.

**EL 576 Fundamentals of Radar**

Principles of range and direction finding by means of radio 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 561.

**EL 577 Radiation and Diffraction I, II**

EL 777-778 Ultrasonics I, II* each 2 ½:0:3
Wave propagation in solids and applications to microwave acoustic devices and ultrasonic nondestructive evaluation. Elasticity and piezoelectricity in crystals, stress-strain relation, piezoelectric coupling, crystal symmetry. Plane wave propagation and reflection, Rayleigh, Love and other guided waves, leaky waves. Devices treated include interdigital transducers and filters, HAGS, real-time and storage correlators and convolvers. EL 777 prerequisite: EL 772. EL 778 prerequisite: EL 777.

EL 871 Advanced Ray Methods in Wave Propagation* 2 ½:0:3
Asymptotic theory of radiation and diffraction, with emphasis on inhomogeneous and dispersive media. WKBJ approximations and companion methods, advanced saddle-point techniques and relation to ray optics. Space-time propagation of inhomogeneous dispersive media, diffraction and transition phenomena for transients. Prerequisite: EL 772.

EL 873 Nonlinear Waves* 2 ½:0:3

EL 870 Microwave Engineering Laboratory* 1:4:0
Experiments with microwave sources (electron tube and solid state), rectangular waveguide components, power measurements, resonance cavities, non-reciprocal devices, microwave integrated circuits, S-parameter measurements, semiconductor devices, noise measurements, computer simulation, and surface acoustic wave measurements. Enrollment limited. Laboratory fee required. Prerequisites: EL 571, EL 545, and the approval of the microwave program advisor.

EL 971-972 Selected Topics in Electromagnetic Theory I, II 2 ½:0:3
Aspects of electromagnetic and acoustic wave propagation, diffraction and radiation 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 581† Introduction to Plasma Engineering* 2 ½:0:3
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 ½:0:3
Analysis of linear and nonlinear fields. Kinetic and hydrodynamic descriptions of many-particle systems at both quasilinear and nonlinear levels. Wave-particle and wave-particle interactions treated as collision processes both classically and quantum theoretically. Determination of self-consistent kinetic equations for particles and waves. Applications to space-time evolution of coupled background magnetic field and turbulent waves. EL 781 prerequisite: graduate status. EL 782 prerequisite: EL 781. Also listed under AM 973-974

EL 783-784 Linear Wave Process in Plasmas I, II* each 2 ½:0:3
Oscillatory and 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.

EL 981-982 Selected Topics in Plasma I, II* each 2 ½:0:3
Aspects of plasmas of current interest. Subjects drawn from plasma composition dynamics and interactions with electromagnetic fields. (See departmental mailing for detailed description of each particular offering.) Prerequisite: specified when offered.

DEPARTMENT PROJECTS, READINGS, THESIS AND SEMINAR

EL 891 Graduate Seminar* 2 ½:0:3
Seminars in various areas of electrical engineering, electrophysics, 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 5:0:3
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 2 ½:0:3
Designed primarily for students who desire to push toward frontiers of their specialization in electrical engineering, electrophysics or system engineering and who have completed essentially all related course offerings. Readings conducted under guidance of a 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 electrophysics for the advanced graduate student. Projects assigned on basis of specialized interest and preparation of the student. A written report or oral examination is required at the discretion of the advisor. 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 formal, bound thesis volume required. Registration of 9 units required (continuous thesis registration required). Prerequisite: degree status.

EL 998 Projects for Engineer Degree in Electrical Engineering each 3 units
Comprehensive planning and design of electrical engineering project under guidance of faculty adviser. Emphasis on current techniques. Oral examination and formal, bound report required. Scope of project is 6-12 units by prior agreement with adviser (continuous project registration required). Prerequisite: degree status.

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 journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: passing qualifying examination. Registration beyond twelfth 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

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 communication networks, telecommunications

Frank A. Cassara, Professor of Electrical Engineering B.S., Rutgers—The State University; M.S., Ph.D., Polytechnic Institute of Brooklyn
Electronic circuits, communication systems

Edward S. Cassedy, Professor of Electrical Engineering B.S., Union College; S.M., Harvard University; Dr.Eng., The Johns Hopkins University
Power, plasmas, energy economics

Bernard R.-S. Cheo, 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

Leopold B. Felsen, Institute Professor B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn
Propagation and diffraction, optics

Stanley H. Gross, Professor of Electrophysics B.S., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn
Ionospheric plasmas and atmospheric physics

Alexander Hassel, 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

Aaron Kereshenbaum, Professor of Computer Science B.S., M.S., Polytechnic Institute of Brooklyn; Ph.D., Polytechnic Institute of New York
Computer communications, algorithms

Erich E. Kunhardt, Professor of Electrophysics and Director, Weber Institute B.S., M.S., New York University; Ph.D., Polytechnic Institute of New York
Gaseous electronics, plasma dynamics, pulse power physics

Frank Kozin, Professor of System Engineering B.S., M.S., Ph.D., Illinois Institute of Technology
Stochastic systems

Szu-Ping Kuo, Professor of Electrical Engineering and Electrophysics B.S., M.S., National Chiao-Tung University (Taiwan); Ph.D., Polytechnic Institute of New York
Magnetohydrodynamics

Ludwik Kurz, Professor of Electrical Engineering B.E.E., M.E.E., CCNY; Eng. Sc.D., New York University
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
ELECTRICAL ENGINEERING

Frank J. Lupo, Professor of Electrical Engineering and Computer Science
B.E.E., M.E.E., New York University; Ph.D., Columbia University
Bioengineering, networks, and systems

Eli Abasalom Mishkin, Professor of Applied Physics
Ingenieur, Sc.D., Technion (Israel)
Quantum and nonlinear optics, laser-induced fusion

Istvan Palocz, Professor of Electrical Engineering and Electrophysics
Dr. D.E., Docent, University of Technical Sciences
(Budapest); Ph.D., Polytechnic Institute of Brooklyn
Wave propagation

Athanasiou Papoulis, Professor of Electrical Engineering
M.E, E.E., Athens Polytechnic Institute (Greece); M.S., M.A., Ph.D., University of Pennsylvania
Signal theory

Henry Rston, 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

Philip E. Sarachik, Professor of Electrical Engineering
A.B., B.S., M.S., Ph.D. Columbia University
Optical 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

Jerry Shmoys, Professor of Electrical Engineering
B.E.E., Cooper Union; Ph.D., New York University
Antennas, propagation

Martin L. Shooman, Professor of Electrical Engineering and Computer Science
S.B., S.M., Massachusetts Institute of Technology; D.E.E., Polytechnic Institute of Brooklyn
Software engineering, system reliability and safety

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

Richard Van Slyke, Professor of Electrical Engineering and Computer Science, Director of the Center for Advanced Technology in Telecommunications
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Computer communications, telecommunications

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, Institute Professor
B.E.E., CCNY; M.S., New York University
Networks, control systems

Douglas A. Davida, Associate Professor of Electrophysics
B.S., M.S., Newark College of Engineering; Ph.D., Johns Hopkins University
Microwave acoustics, quantum electronics

Richard A. Haddad, Associate Professor of Electrical Engineering and Director of Westchester Center
B.E.E., M.E.E., Ph.D., Polytechnic Institute of Brooklyn
Digital filters, power systems

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Computer communication networks, performance evaluation of computer systems

Maurice C. Newstein, Associate Professor of Electrophysics
A.B., Temple University; Ph.D., Massachusetts Institute of Technology
Quantum electronics

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Microwave techniques, biotechnology
Gerhard Schafer, Associate Professor of Electrophysics
Ph.D., University of Berlin
Lasers; high power electronics

Leo M. Silber, Associate Professor of Electrophysics
B.S., University of Massachusetts; M.S., Ph.D., Purdue University
Magnetic materials, plasmas

Zivan Zabar, Associate Professor of Electrical Engineering
B.Sc., M.Sc., Sc.D., Technion (Israel)
Power electronics, electric drives, power systems

Marco Guglielmi, Assistant Professor of Electrical Engineering
B.S., University of Roma (Italy); M.S., Bridgeport University
Electromagnetics, electronics

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B.Sc., M.Sc., Alexandria University (Egypt); M.S.E.E., California Institute of Technology, Ph.D., Purdue University
Microwave magnetics, microwave acoustics
Angelos K. Katsaggelos, Assistant Professor of Electrical Engineering  
B.S.E.E., Aristotelian University of Thessaloniki; M.S.E.E., Ph.D. E.E., Georgia Institute of Technology  
Image restoration, digital communication and signal processing

Hyuk Lee, Assistant Professor of Electronics  
B.S., Seoul National University (Korea); M.S., Ph.D., California Institute of Technology  
Electro-acousto-optical devices

I-Tai Lu, Assistant Professor of Electrical Engineering  
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Electromagnetics, microwave circuits

Shivendra S. Panwar, Assistant Professor of Electrical Engineering  
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Communication networks

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Signal processing

Prodip Sen, Assistant Professor of Electrical Engineering  
B.Tech., Indian Institute of Technology; Ph.D., Indian Institute of Science (Bangalore)  
System theory, signal processing, distributed and parallel processing

ASSOCIATED FACULTY

Myron M. Rosenthal, Industry Professor  
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Radar, microwave techniques, EM/I techniques

Joel B. Snyder, Industry Professor  
B.E.E., M.E.E., Polytechnic Institute of Brooklyn, P.E. (New York, Massachusetts)  
Microprocessor systems, data acquisition and transmission, signal processing

Wen Yuan Xu, Visiting Professor of Electrical Engineering  
E.E., Nankai University (China)  
Stochastic Processes

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

Shalom S. Bergstein, Visiting Assistant Professor of Electrical Engineering  
B.S., M.S., Ph.D., Polytechnic Institute of New York  
Communications, fiber optics

Bernardino M. Penetrante, Research Assistant Professor of Electrophysics  
B.S., State University of New York (Buffalo); Ph.D., University of Pittsburgh  
Gaseous electronics

Vrinda P. Dewal, Academic Associate in Electrical Engineering  
B.E., M.E., University of Rorkee (India)  
Communications, instrumentation

Chi-Ren Liu, Academic Associate in Electrical Engineering  
B.S.E.E., National Taiwan University; M.S., Polytechnic Institute of New York  
Electronic circuits, communication systems

Peter Voltz, Academic Associate in Electrical Engineering  
B.S., M.S.E.E., Polytechnic Institute of New York  
Systems and controls

ADJUNCT FACULTY

Bernard Friedland, Adjunct Professor  
A.B., B.S., M.S., Ph.D., Columbia University

Richard Game, Adjunct Professor  
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George Karady, Adjunct Professor  
Dipl. Eng., Ph.D., Technical University of Budapest (Hungary)

Frederick W. Scholl, Adjunct Associate Professor  
B.E.E., Ph.D., Cornell University

Charles D. Hechtman, Adjunct Assistant Professor  
B.S., M.S., Ph.D., Polytechnic Institute of New York

Faut Agi, Lecturer  
B.S.E.E., M.S.E.E., I.T.O. (Istanbul); P.E. (New York)

John H. Chang, Lecturer  
B.S., National Taiwan University; M.S., Ph.D., Yale University

Jonathan Chao, Lecturer  
B.S., M.S., National Chiao-Tung University (Taiwan); Ph.D., Ohio State University

Leo Eanes, Jr., Lecturer  
B.S., M.S., Polytechnic Institute of New York

Frederick W. Freyre, Lecturer  
B.S., City College of New York; M.S., Rensselaer Polytechnic Institute; Ph.D., Polytechnic Institute of New York

Ralph Gittleman, Lecturer  
B.S., Massachusetts Institute of Technology; M.E.E., Polytechnic Institute of Brooklyn

Jalal Gohari, Lecturer  
B.S.E.E., City College of New York
ELECTRICAL ENGINEERING

Frank Gruppuso, Lecturer  
B.S., M.S., Polytechnic Institute of New York

Howard Hausman, Lecturer  
B.S., M.S., Polytechnic Institute of Brooklyn

John Howard, Lecturer  
B.S., University of Wales; M.S., Ph.D., University of London

Charles W. Kulisan, Lecturer  
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Robert Leahy, Lecturer  
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Jack Richman, Lecturer  
B.C.E., City College of New York; M.S., New York University

Doru T. Roii-Mecag, Lecturer  
B.S., M.S., Polytechnic Institute of New York

Heinz Schreiber, Lecturer  
B.E.E., City College of New York; M.S., Adelphi; Ph.D., Polytechnic Institute of New York

RETIRED FACULTY

Anthony B. Giordano, Professor Emeritus and Dean Emeritus  
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn

Rudolf G.E. Hutter  
State Exam, University of Berlin (Germany); Ph.D., Stanford University

William A. Lynch, Professor Emeritus  
M.E., M.E.E., Polytechnic Institute of Brooklyn

Nathan Marcuvitz, Institute Professor Emeritus  
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn

Arthur A. Oliner, Professor of Electrophysics  
B.A., Brooklyn College; Ph.D., Cornell University

Marvin Panzer  
B.E.E., Cooper Union; M.E.E., D.E.E., Polytechnic Institute of Brooklyn

Beulah Rudner, B.A., Hunter College; M.E.E., Polytechnic Institute of Brooklyn

Sidney S. Shamia, Professor of Electrical Engineering and Associate Provost  
B.E.E., Cooper Union; M.S., Stevens Institute of Technology

Edward J. Smith, Professor of Electrical Engineering and Computer Science  
B.E.E., Cooper Union; M.E.E., D.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)

Gerald Weiss, Professor of Electrical Engineering  
B.E.E., Cooper Union; S.M., Harvard University; D.E.E., Polytechnic Institute of Brooklyn; P.E. (New York)
ELECTROPHYSICS PROGRAM

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 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 an 800-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, 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. An overall grade average of B in all undergraduate courses is required by the University. 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
   - EL 581 Introduction to Plasma Engineering
   - EL 611 Signals, Systems and Transforms
   - EL 651 Statistical Mechanics
   - EL 653 Quantum Electronics
   - EL 671 Fields and Waves
   - 9 units

2. Two one-year sequences, which may include the above courses. Both of these one-year sequences must be in electrical engineering or physics courses, and at least one must be an EL sequence. 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.
ELECTROPHYSICS

REQUIREMENTS FOR THE DOCTOR'S DEGREE

Graduate students who have demonstrated a high degree of scholastic proficiency and have given evidence of ability to conduct 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 Electrical Engineering graduate office.

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 advisor. Oral thesis defense and formal, bound thesis volume required. Registration of 9 units required (continuous thesis registration required). Prerequisite: degree status.

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 a recognized journal. Candidate must successfully defend dissertation orally. Registration of 24 units required (continuous dissertation registration required). Prerequisite: passing of qualifying examination. Registration beyond twelfth unit requires passing of area examination.

PARTICIPATING FACULTY

Edward S. Cassidy, Professor of Electrical Engineering
Bernard R-S Cheo, Professor of Electrical Engineering
Leopold B. Felsen, Institute Professor
Stanley H. Gross, Professor of Electrophysics
Alexander Heasell, Professor of Electrophysics
Erich E. Kunhardt, Professor of Electrophysics
Szu-Ping Kuo, Professor of Electrical Engineering and Electrophysics
James T. LaTourrette, Professor of Electrophysics
Enrico Levi, Professor of Electrophysics
Eli Absalom Mishkin, Professor of Applied Physics
Istvan Palocz, Professor of Electrical Engineering and Electrophysics
Harry Schachter, Professor of Electrical Engineering
Benjamin Senitzky, Professor of Electrophysics
Jerry Shmoya, Professor of Electrical Engineering
Theodor Tamir, Professor of Electrical Engineering and Electrophysics
Wen-Chung Wang, Professor of Electrical Engineering and Electrophysics
Douglas A. Davids, Associate Professor of Electrophysics
Maurice C. Newstein, Associate Professor of Electrophysics
Saul W. Rosenthal, Associate Professor of Electrophysics
Gerhard Schaefer, Associate Professor of Electrophysics
Leo M. Silber, Associate Professor of Electrophysics
Macro Guglielmi, Assistant Professor of Electrical Engineering
Samy M. Hanna, Assistant Professor of Electrical Engineering
Hyuk, Lee, Assistant Professor of Electrophysics
I-Tai Lu, Assistant Professor of Electrical Engineering
Leo Birenbaum, Research Associate Professor of Electrical Engineering and Electrophysics
Bernardino M. Penetrante, Research Assistant Professor of Electrophysics
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 resources at Polytechnic to provide cohesive curricula in technological, economic, managerial, social, political and humanistic areas. Thus Polytechnic resources are applied to education for global, regional and local energy problems.

**GRADUATE PROGRAMS IN ENERGY ENGINEERING AND POLICY**

Interdisciplinary programs in energy engineering and policy lead to master's degrees in 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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</thead>
<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 courses are cross-listed in all participating departments and accepted as departmental courses. Students may enter the energy programs in 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 participating departments.

**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. Students must satisfy minimum requirements of master of science programs in the department.
   b. Students 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. Students must complete four additional courses from 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 below under electives.

2. **Certificates in Energy Policy and Engineering** Upon 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.

<table>
<thead>
<tr>
<th>Course</th>
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<th>Units</th>
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<tr>
<td>ES 927</td>
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**TYPICAL PROGRAMS**

### Chemical Engineering

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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 Thermodynamics I, II</td>
<td>6</td>
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<tr>
<td>CH 781</td>
<td>Chemical Reactor Design I</td>
<td>3</td>
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<tr>
<td>CH 821</td>
<td>Process Dynamics &amp; Control*</td>
<td>3</td>
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<tr>
<td>CH 902</td>
<td>Guided Studies in Chemical Engineering</td>
<td>6</td>
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<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
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<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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### Civil Engineering

Required courses dependent upon C.E. option selected:

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<th>Course</th>
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<tbody>
<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
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<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
<td>3</td>
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<tr>
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</table>

Additional energy electives or other electives must be approved by departmental graduate advisers.

### Electrical Engineering

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>EL 531</td>
<td>Probability</td>
<td>3</td>
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<tr>
<td>EL 610</td>
<td>Linear Systems</td>
<td>3</td>
</tr>
<tr>
<td>EL 611</td>
<td>Signals, Systems and Transforms</td>
<td>3</td>
</tr>
<tr>
<td>EL 651</td>
<td>Intro. to Power System Engineering*</td>
<td>3</td>
</tr>
<tr>
<td>EL 662</td>
<td>Intro. to Power System Planning*</td>
<td>3</td>
</tr>
<tr>
<td>EL 665</td>
<td>Power System Stability I</td>
<td>3</td>
</tr>
<tr>
<td>EL 666</td>
<td>Power System Stability II*</td>
<td>3</td>
</tr>
<tr>
<td>EL 671</td>
<td>Fields and Waves</td>
<td>3</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>
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</table>

**Recommended Electives:**

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
<td></td>
</tr>
<tr>
<td>EL 621</td>
<td>Feedback Control I*</td>
<td></td>
</tr>
<tr>
<td>EL 647</td>
<td>Power Electronics*</td>
<td></td>
</tr>
<tr>
<td>EL 663</td>
<td>Electrical Translators in Power Systems*</td>
<td>9</td>
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<tr>
<td>EL 664</td>
<td>Relay Fault Protection*</td>
<td></td>
</tr>
<tr>
<td>EL 568</td>
<td>Electric Drives I*</td>
<td></td>
</tr>
<tr>
<td>EL 569</td>
<td>Electric Drives II*</td>
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</tr>
<tr>
<td>EL 961-2</td>
<td>Selected Topics in Power I, II</td>
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</table>

### Energy Management

<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>
</tbody>
</table>

*Also energy elective
ENERGY

ES 928 Energy Resources and Conversion Technology 3

Electives: select two
MG 631 Theories of Complex Organizations* 6
MG 640 Resource Economics* 6
MG 664 Legal Environment of Business* 6
MG 865 Research, Development and Management of Innovation* 6
MG 866 Technology Management and Policies 6

Additional electives must be approved by management division graduate advisers. 24

Industrial Engineering
IE 611 Statistical Quality Control* 3
IE 619 Production Planning and Controls 3
IE 628 Operations Research: Stochastic Models 3

Major electives 12
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3

Electives 9

Management
MG 600 Management Processes 3
MG 601 Organizational Behavior 3
MG 602 Computers in Management 3
MG 603 Economic Environment of Management** 3
MG 604 Managerial Accounting‡ 3
MG 605 Statistical Analyses‡ 3
MG 606 Managerial Finance 3
MG 607 Marketing Management 3
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3

Energy electives 9
Additional electives must be approved by departmental graduate advisers. 9

Aerospace Engineering or Mechanical Engineering
(Mechanical analyses and design options)
AM 601-02 Stress Analysis I, II 6
AM 651-2 Advanced Dynamics I, II 6
AM 653-54 Dynamics of Machines: Mechanical Vibrations 6
AM 971-72 Seminar in Mechanical and Aerospace Engineering* 0

Major area electives 6
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3

Energy electives 12

Metallurgy
MT 610 Thermodynamics of Metals and Alloys 3
MT 620 Plastic Deformation and Fracture 3
MT 640 Reactions in Solids 3
ES 927 Energy Policy Issues 3
ES 928 Energy Resources and Conversion Technology 3

Energy electives 12

Major area electives, electives approved by departmental graduate adviser, and project or thesis. 9

Operations Research
IE 600 Engineering Economy 3
IE 631 Linear Programming* 3
IE 650 Queuing 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 Characteristics of Transportation Demand 3
TR 601 Travel Demand Forecasting* 3
TR 629 Transportation Workshop 3
TR 630 Urban Planning Principles 3
TR 701 Traffic Engineering 3
TR 750 Transportation Economics and Finance 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 9

Transportation Management
MG 600 Management Process 3
MG 604 Managerial Accounting 3
TR 600 Characteristics of Transportation Demand 3
TR 751 Transportation Financial Control 3

*Also energy elective
‡ Suitable equivalent course is acceptable
‡ Suitable equivalent course is acceptable

122
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>TR 757</td>
<td>Transportation Management</td>
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<tr>
<td>ES 927</td>
<td>Energy Policy Issues</td>
<td>3</td>
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<tr>
<td>ES 928</td>
<td>Energy Resources and Conversion Technology</td>
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<tr>
<td>TR 966</td>
<td>Master's Project in Transportation Management</td>
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## ACCEPTABLE ENERGY ELECTIVES

### Energy Conversion

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>AM 761</td>
<td>Energy Conversion</td>
<td>3</td>
</tr>
<tr>
<td>AM 763</td>
<td>Solar Thermal Engineering I</td>
<td>3</td>
</tr>
<tr>
<td>AM 764</td>
<td>Solar Thermal Engineering II</td>
<td>3</td>
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<tr>
<td>AM 769</td>
<td>Special Topics in Energy Conversion</td>
<td>3</td>
</tr>
<tr>
<td>CH 791</td>
<td>Electrochemical Engineering</td>
<td>3</td>
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<tr>
<td>EL 564</td>
<td>Electromechanical Power Conversion</td>
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</table>

### Energy Transfer Processes

<table>
<thead>
<tr>
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<th>Course Title</th>
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<tbody>
<tr>
<td>AM 711</td>
<td>Convective Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 712</td>
<td>Conductive Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 713</td>
<td>Radiative Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 715</td>
<td>Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 716</td>
<td>Reactor Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 717</td>
<td>High Performance Heat Exchangers</td>
<td>3</td>
</tr>
<tr>
<td>AM 718</td>
<td>Multi-phase Flows with Heat Transfer</td>
<td>3</td>
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<tr>
<td>CH 756</td>
<td>Process Heat Transfer</td>
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</table>

### Environmental Impact of Energy Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AM 685</td>
<td>Noise and Acoustics I</td>
<td>3</td>
</tr>
<tr>
<td>AM 686</td>
<td>Noise and Acoustics II</td>
<td>3</td>
</tr>
<tr>
<td>AM 751/CE</td>
<td>Aerodynamics of the Urban Environment I</td>
<td>3</td>
</tr>
<tr>
<td>AM 752/CE</td>
<td>Aerodynamics of the Urban Environment II</td>
<td>3</td>
</tr>
<tr>
<td>CE 741</td>
<td>Analysis of Water Quality Systems</td>
<td>3</td>
</tr>
<tr>
<td>CE 747</td>
<td>Analysis of Stream and Estuary Systems</td>
<td>3</td>
</tr>
<tr>
<td>CE 752</td>
<td>Air Pollution</td>
<td>3</td>
</tr>
<tr>
<td>CE 758/CH</td>
<td>Air Pollution Engineering Control</td>
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<tr>
<td>TR 630</td>
<td>Urban Planning Principles</td>
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### Fluid Energy Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>AM 718</td>
<td>Multiphase Flows with Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>AM 746</td>
<td>Fluid Dynamics of Rotating Machinery</td>
<td>3</td>
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<tr>
<td>AM 749</td>
<td>Magnetofluid Dynamics</td>
<td>3</td>
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### Machinery

<table>
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<tr>
<td>EL 668</td>
<td>Electric Drives I</td>
<td>3</td>
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<tr>
<td>EL 669</td>
<td>Electric Drives II</td>
<td>3</td>
</tr>
<tr>
<td>AM 746</td>
<td>Fluid Dynamics of Rotating Machinery</td>
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### Management and Economics of Energy Systems

<table>
<thead>
<tr>
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<tr>
<td>MG 603</td>
<td>Economic Environment of Management</td>
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<td>MG 631</td>
<td>Organization Theory</td>
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### Energy

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<tr>
<td>MG 654</td>
<td>Management and the Legal System</td>
<td>3</td>
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<tr>
<td>MG 800</td>
<td>Policy Analysis and Planning</td>
<td>3</td>
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<td>MG 866</td>
<td>Technology Management and Policy</td>
<td>3</td>
</tr>
<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
<td>3</td>
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<tr>
<td>IE 620/MG</td>
<td>Project Planning and Control</td>
<td>3</td>
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<tr>
<td>SS 675</td>
<td>Technology Transfer to Developing Countries</td>
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<tr>
<td>IE 665</td>
<td>Microeconomic Models</td>
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<td>MG 640</td>
<td>Resource Economics</td>
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<td>MG 671</td>
<td>Business and Economic Forecasting</td>
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<tr>
<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>AM 765</td>
<td>Energy Conversion and Environmental Controls</td>
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### Materials

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<tr>
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<tbody>
<tr>
<td>MT 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</td>
<td>3</td>
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<td>MT 700</td>
<td>Nondestructive Testing</td>
<td>3</td>
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<tr>
<td>MT 715</td>
<td>Welding Metallurgy</td>
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<td>CH 917</td>
<td>Introduction to Polymeric Materials I</td>
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### Plasma and Controlled Fusion

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<tr>
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<td>Introduction to Plasma Engineering</td>
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<tr>
<td>EL 667</td>
<td>Introduction to Thermonuclear Power</td>
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### Power Plant Construction and Engineering

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<tbody>
<tr>
<td>CE 625/AM</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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<tr>
<td>CE 711</td>
<td>Hydraulic Design of Structures</td>
<td>3</td>
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<td>CE 890</td>
<td>Earthquake Engineering I</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>
<td>3</td>
</tr>
<tr>
<td>AM 632/CE</td>
<td>Introduction to 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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<tr>
<td>AM 675</td>
<td>Mechanical Servomechanisms I</td>
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<tr>
<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</td>
<td>System Reliability</td>
<td>3</td>
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<tr>
<td>EL 618/IE</td>
<td>Component Reliability</td>
<td>3</td>
</tr>
<tr>
<td>EL 621</td>
<td>Feedback Control I</td>
<td>3</td>
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<tr>
<td>EL 622</td>
<td>Feedback Control II</td>
<td>3</td>
</tr>
<tr>
<td>EL 647</td>
<td>Power Electronics</td>
<td>3</td>
</tr>
<tr>
<td>EL 661</td>
<td>Intro. to Power System Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EL 663</td>
<td>Electrical Transients in Power Systems</td>
<td>3</td>
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<tr>
<td>EL 664</td>
<td>Relay Fault Protection</td>
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ENERGY

System Organization
EL 665 Power System Stability I 3
EL 666 Power System Stability II 3
IE 611 Statistical Quality Control 3
IE 612 Advanced Quality Control 3
IE 765 Human Factors in Engineering Design 3
IE 775 Industrial Safety Engineering 3

Thermodynamics, Combustion and Chemical Processes
AM 701 Thermodynamics I 3
AM 704 Aerothermochemistry 3
AM 705 Combustion I 3
AM 706 Combustion II 3
CH 771 Chemical Engineering Thermodynamics I 3
CE 770 Solid Waste Management 3

Transportation
TR 660 Urban Public Transportation 3

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 $ 2 1/2:0:3
Review of economic and societal aspects of energy production and consumption; energy demands; exhaustible energy resources; contemporary energy technologies and their problems; fossil fuel technologies; nuclear fission; technical efficiency; energy logistics. Alternative energy technologies — short, medium and long term prospects; energy R & D; societal perspectives. Policy analyses; energy policy frameworks.

ES 928 Energy Resources and Conversion Technologies $ 2 1/2:0:3
Summary of present energy resources and global energy requirements; twentieth-century advances in science and technology being applied or soon to be applied to United States energy economics. Attention to principles behind practical devices and to limitations 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 * 2 1/2:0:3
Topics of current interest: energy economics; energy resources; social impact of energy technologies. Available for credit in lieu of ES 928, when offered, as the second required course of the energy program.

PARTICIPATING FACULTY

STEERING COMMITTEE

Edward S. Cassedy, Jr., Professor of Electrical Engineering
Chair, Energy Program Steering Committee

Irving Cadoff, Professor of Physical and Engineering Metallurgy

Joachim I. Weindling, Professor of Operations Research and System Engineering

Anthony J. Weiner, Professor of Management

Paul 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, 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. Molof, Associate Professor of Civil and Environmental Engineering

Zivan Zabar, Associate Professor of Electrical Engineering and Computer Science
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 programs and the undergraduate concentrations exploit the advantages and strengths of a technological university and thus are particularly beneficial to students who combine strong interests in the humanities or journalism and technical writing with interests 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 as intellectually comfortable in the sciences as in the arts and humanities. While such persons are rare, they are in demand in virtually every profession and can expect to fill vital roles in fields which are only now being explored. These programs give men and women in the humanities and in communications integrated educations.

The department also plays an essential role in the education of students who are majors in other departments. Today's engineers and scientists must know the humanities in order to make well-reasoned decisions involving human values implicit in technological options, to understand the ways human beings see themselves and the natural and social worlds, and to communicate effectively.

As freshmen, all students admitted to Polytechnic University are placed at appropriate levels in the freshman English sequence. On the basis of an English composition placement test evaluated by the department, most students are 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 of the sequence; others may first be required to take one or more semesters of 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, non-majors are 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 providing a coherent introduction to the humanities. Courses in public speaking and technical writing are especially practical for students preparing for careers in engineering or science. Advising booklets are available which list recommended sequences of courses in the humanities and social sciences. See Degree Requirements for further information.

*IS 140-141 may be taken in place of HU 200 and SS 104. See the Humanities and Social Sciences requirements on page 60.
HUMANITIES AND COMMUNICATIONS

departmental adviser. Generally they also fulfill the require-
ments of the contemporary liberal arts core curriculum
outlined in that section of the catalog, pp. 95-97. 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 Bachelor of Science
Degrees in Humanities

<table>
<thead>
<tr>
<th>Course Type</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Curriculum</td>
<td></td>
</tr>
<tr>
<td>Humanities (HU 101 and HU 200) *</td>
<td>6</td>
</tr>
<tr>
<td>Social Sciences (SS 104) *</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics &amp; Computers</td>
<td>3</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>
<tr>
<td>Humanities Courses</td>
<td>39</td>
</tr>
<tr>
<td>Electives</td>
<td></td>
</tr>
<tr>
<td>Social Sciences electives</td>
<td>6</td>
</tr>
<tr>
<td>Free electives</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Total credits required for graduat</td>
<td>126</td>
</tr>
</tbody>
</table>

Dual majors and degrees—A number of students elect
to pursue dual majors—one in journalism and technical
writing and another in engineering or science. Besides
completing all requirements for degrees in engineering or
science, students must complete 33 credits of communica-
tions courses in the Department of Humanities and
Communications. These courses must be approved by a
departmental adviser. Other combinations are possible,
such as a dual major in the humanities and social sciences
or management. Students may also pursue two separate
degrees. In such instances, the 33 credits of communications
or humanities courses must be over and above any
humanities and communications courses required for the
first degree.

Interdisciplinary Studies—The purpose of the interdisci-
plinary studies program, sponsored by the Department
of Humanities and Communications and the Department
of Social Sciences, is to enhance the humanistic elements
of education. The program promotes courses, seminars and
special lectures demonstrating the fruitfulness of interdisci-
plinary 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 Bachelor of Science degree
programs in Social Sciences or the Humanities. For a full
description, see section entitled Contemporary Liberal
Arts Core Curriculum, page 95.

GRADUATE PROGRAMS

Specialized Journalism

The Department of Humanities and Communications offers
Master of Science degrees in Specialized Journalism. To
be eligible for admission to this program, applicants 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, geogra-
phy, 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 require-
ments for admission—but are required to take undergradu-
ate courses to fulfill the basic requirements for admission.
No graduate credits are given for such undergraduate
courses taken to meet deficiencies.

In general, applicants should have a minimum undergradu-
ate grade point average of 3.0 from an accredited college
or university. However, candidates with lower grade-point
averages may be considered if they have demonstrated
success in some area of professional writing. Others with
lower grade-point averages may be admitted provisionally
or 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 professional
journalists who can write about business and financial
developments and trends for both knowledgeable business
professionals and market analysts as well as the general
public. Writers should have a solid background in econom-
ics 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 comprehensively. Clear,
crisp, concise writing is a necessity.

Trade-Magazine Journalism

Trade-magazine journalism entails writing and editing news
and feature articles for technical and marketing-oriented
publications serving particular industries. Such publica-
tions may be owned by independent publishing compa-
nies, professional societies or large corporations.

Medical and Science Reporting

Medical and science writers or editors work on magazines
serving physicians, nurses and other technical and scientif-
ic personnel; on the news staffs of print and broadcast
media; on public relations staffs of pharmaceutical houses
and hospitals, medical schools and research centers; in
the writing departments of corporations; and in editing departments of textbook publishers. In addition to writing clearly and succinctly, writers and editors must have sound backgrounds in the sciences.

Industrial Advertising and Public Relations

Industrial advertising and public relations work is concerned with the promotion of corporate products and the ability 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 in this profession work as copywriters, account executives, advertising managers and media directors.

Industrial public relations work has the same overall goals 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 clients’ industries, hold press conferences to announce new products and technology developed by client companies, prepare feature articles on company products for publication in trade magazines and technical journals, write speeches for engineering and management personnel and prepare corporate literature (product brochures, annual reports, house organs and other technical and semi-technical material) for distribution to corporate customers.

Technical Writing

Technical writers — also called publications engineers and engineering writers — gather, organize, write and edit technical and scientific materials for management and technical personnel within their own companies 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. Technical writers may also be called upon to write speeches and trade-magazine articles for scientists and engineers.

Requirements for Master of Science Degrees

M.S. degrees requires 36 units of graduate work. All students must take JW 606 (Legal Law and Press Ethics), JW 701 (Specialized Project in Professional Writing) and four courses (12 units) selected from the following list in consultation with advisers:

<table>
<thead>
<tr>
<th>Units</th>
<th>JW 607 Introduction to Specialized Journalism 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>JW 601 Style for the Professional Writer 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 602 Proposal Writing 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 603 Reporting on Science, Technology and Medicine 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 604 Graphics and Production 3</td>
</tr>
</tbody>
</table>

HUMANITIES AND COMMUNICATIONS

JW 607 Techniques Writing News for Radio and Television 3

The remaining 18 units are taken in elective courses. Generally, students select electives from among the remaining graduate courses offered in the department. Students who wish to enhance their scientific and technical knowledge or who are interested in management or social sciences courses may take a maximum of nine credits of graduate courses in other departments of Polytechnic University. Approval for this option must be given by the head of the department.

Elective courses are usually conducted as workshops, providing students with the kinds of writing and editing assignments they receive when 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>Units</th>
<th>JW 608 Introduction to Documentation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>JW 609 Computer Documentation 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 620 Financial and Business Reporting 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 621 Reporting and Editing for the Business Press 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 622 Writing Copy for Industrial Public Relations 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 623 Publications Management and Budgeting 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 641 Graphics Workshop 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 701 Special Project in Professional Writing 3</td>
</tr>
</tbody>
</table>

Trade-Magazine Journalism

<table>
<thead>
<tr>
<th>Units</th>
<th>JW 510 Technical Writing about Digital Electronics I 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>JW 520 Technical Writing about Digital Electronics II 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 608 Introduction to Documentation 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 609 Computer Documentation 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 620 Financial and Business Reporting 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 621 Reporting and Editing for the Business Press 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 622 Writing Copy for Industrial Public Relations 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 624 Writing Product-Information Copy 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 641 Graphics Workshop 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 701 Special Project in Professional Writing 3</td>
</tr>
</tbody>
</table>

Medical and Science Reporting

<table>
<thead>
<tr>
<th>Units</th>
<th>JW 603 Reporting on Science, Technology and Medicine 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>JW 608 Introduction to Documentation 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 609 Computer Documentation 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 621 Reporting and Editing for the Business Press 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 625 Advanced Medical Reporting 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 626 Medical Public Relations 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 627 Writing Copy on Pharmaceuticals and Drugs 3</td>
</tr>
<tr>
<td>Units</td>
<td>JW 641 Graphics Workshop 3</td>
</tr>
</tbody>
</table>

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HUMANITIES AND COMMUNICATIONS

JW 701 Special Project in Professional Writing 3

Industrial Advertising and Public Relations
JW 608 Introduction to Documentation 3
JW 609 Computer Documentation 3
JW 621 Reporting and Editing for the Business Press 3
JW 622 Writing Copy for Industrial Public Relations 3
JW 624 Writing Product-Information Copy 3
JW 628 Writing Industrial Advertising Copy 3
JW 629 Writing the Marketing Report 3
JW 641 Graphics Workshop 3
JW 701 Special Project in Professional Writing 3

Technical Writing
JW 510 Technical Writing about Digital Electronics I 3
JW 520 Technical Writing about Digital Electronics II 3
JW 603 Reporting on Science, Technology and Medicine 3
JW 609 Introduction to Documentation 3
JW 609 Computer Documentation 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 641 Graphics Workshop 3
JW 701 Special Project in Professional Writing 3

CERTIFICATE PROGRAM IN A FIELD OF SPECIALIZATION

Certificates in specialized journalism are available to students completing five courses with grades of B or higher. Courses must be taken in a prescribed sequence arranged with an adviser. Students enrolled in the certificate program must meet the same rigorous standards of performance required of those working for M.S. degrees. At any time during enrollment, or following the awarding of the certificate, students in this program may transfer into the master's degree program if their performance has been satisfactory and they meet the standards for admission set by the department. Transfer into the master's program, however, may not mean automatic acceptance of all courses which students have taken while working toward certificates. Acceptance of credits depends upon the area of specialization in which students plan to work for degrees.

ENGLISH AND HUMANISTIC STUDIES AND MODERN LANGUAGES

Advanced courses and seminars in the humanities may 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 minors in the humanities to fulfill parts of their requirements for advanced degrees. Advisers in the Department of Humanities and Communications are available to recommend appropriate courses for such minors.

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. Development of grammatical control in reading and writing, and improved comprehension of college-level texts. Practice in listening and speaking; intensive preparation in language skills for academic and professional purposes. Graduates may register with permission of the 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 Writing and the Humanities I 3:0:3

Introduction to the humanities and to effective techniques of college-level writing. Examination of basic concepts, forms, and techniques of philosophy, art, and literature, with emphasis on fluency, precision and imaginative use of source materials in writing. Admission by placement examination.

HU 103 Writing and the Humanities I (English as a Second Language) 6:0:0

Introduction to the humanities and to effective techniques of college-level writing, designed for students taking English as a second language. Examination of basic concepts, forms, and techniques of philosophy, art, and literature, with emphasis on fluency, grammar, syntax, precision and imaginative use of source materials in writing. Admission by placement examination.

HU 200 Writing and the Humanities II 3:0:3

Introduction to the humanities and to advanced techniques in writing. Thematic emphasis on change and continuity in the humanities and an exploration of the relationship of the humanistic disciplines through study of great works of art, philosophy, and literature, and, in some sections, music. Advanced work in stylistic options and more complex forms of writing: the longer critical essay, the formal report, the research paper. Prerequisite: HU 101 or HU 103 or advanced placement.

JOURNALISM AND TECHNICAL WRITING

Please note: HU 101 or HU 103 is a prerequisite for all courses in this section except for HU 121, which has no prerequisite.

HU 105 Advanced Composition 3:0:3

Lucid expository writing. 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

Development of students' interviewing and writing skills to produce a medium-to-long-length magazine articles. With instructor's help, students develop story ideas on technical or non-technical subjects, complete the necessary library research and personal interviews and write pieces for specific publications. Students are encouraged to publish their work, although this is not a specific course requirement. Students also examine editorial practices of various popular, business and technical magazines and learn how successful magazine articles are put together.
HU 108 News Writing 3:0:3
Workshop to guide students in all basic news writing techniques. Writing of leads. Style and structure 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 slating, in dramatizing, in outlining and writing minimum of three articles.

HU 110 Basic Report Writing I 3:0:3
Fundamentals of report writing applied 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. Summaries, process and technical descriptions, instructions, analyses. Effective style, organization of material and mechanics. Students learn to coordinate tables, graphs and other illustrative matter with textual matter.

HU 111 Basic Report Writing II 3:0:3
Writing the longer technical forms commonly used in industry. Technical proposals, sections of manuals; letter reports, formal reports, technical sales literature, and semi-technical and technical articles for trade journals.

HU 112 Advanced Copyediting Techniques 3:0:3
Improvement of students' editorial skills through intensive practice in writing headlines, decks and subheads for both general and industrial publications and through assignments in editing, revising and rewriting copy intended for a variety of publications. Writing leads and reorganizing garbled copy. Newspaper and magazine page layout and makeup.

HU 113 Writing for Advertising and Public Relations 3:0:3
Writing effective advertising copy and publicity releases with emphasis on the industrial side. Students write product ads, brochure copy, product data sheets, news releases, short articles for trade journals, copy for house organs and speeches. Preparation and implementation of a typical advertising campaign and arrangements for press conferences. Layout of ad copy and accompanying color, design, typographic and illustrative features.

HU 114 Libel Law and Ethical Issues in Journalism 3:0:3
What libel is and how writers can avoid its many pitfalls. Complete and partial defenses raised during libel suits and the possible damages awarded, the principles of "fair comment and criticism," criminal and civil libel, and one's right to privacy vs. the public's "need to know." The ethical issues facing journalists and other writers today, concerning writing about new products and technology believed to be defective or hazardous, pornography and the courts, shield laws, gag orders and copyrights.

HU 115 Reporting and Writing about Science and Technology 3:0:3
How to interview scientists and engineers and how to present the information obtained in formats understandable to the layman. Students write both news and feature stories, and are encouraged to publish their best pieces.

HU 116 Introduction to Computer Documentation 3:0:3
Computer systems and software documentation. The history of computer documentation, the role of documentation specialists, basic concepts and techniques, types of manuals; planning and management documentation. Prerequisite: one technical writing course and basic familiarity with computers. This course cannot be used to satisfy the HU/SS elective requirements.

HU 121 Public Speaking 3:0:3
Training and practice in speaking before groups, preparation of materials for oral presentations, extemporaneous speaking, individual criticisms by instructor and fellow students. Special sections for English as a Second Language students also include work with pronunciation and vocabulary.

HU 125 Reporting and Writing for the Wire Services 3:0:3
Reporting, writing, and editing the news under the pressure of tight deadlines. Many assignments require field research as this course attempts to simulate a wire-service reporter's daily experiences. Trips to AP and UPI headquarters are arranged. Reporting accuracy, thoroughness and good journalistic style stressed. Wire-service history and editorial practices covered.

HU 130 Creative Writing I 3:0:3
The art and craft of writing poetry, fiction and drama. Students experiment with all genres. Students' own work stressed. Weekly written assignments discussed and criticized.

HU 131 Creative Writing II 3:0:3
Advanced art and craft of writing poetry, fiction and drama. Application of individual 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.

HU 135 Introduction to Corporate Communications 3:0:3
Intensive study, through a review of case histories and writing assignments requiring field research, of all aspects of editorial work in the communications department of a medium-sized or large corporation. Students research, write and edit copy for press releases, newsletters, proposals, house organs, community-relations campaigns, brochures, and annual reports. Business correspondence, short nontechnical memos and reports, and formats for minutes of meetings and job descriptions.

HU 136 Writing Annual Reports 3:0:3
The single most important document produced by a corporation is its annual report. Students learn and practice procedures by which such a publication is written and produced: planning, scheduling, researching, writing, editing, graphics and production.

HU 140 Proposal Writing 3:0:3
Solicited and unsolicited proposals in government and private sectors covered. Elements of typical proposals, such as statements of the problem, technical discussions, how teams organize to perform work, fiscal information, technical competence of companies to perform the task and key personnel discussed. Students prepare an outline and write a proposal on a specific topic as the major course assignment.

HU 141 Graphics and Production Techniques 3:0:3
Graphic design and production techniques and procedures for technical writers and editors. Magazine layout and production of technical reports, manuals and proposals. Composition methods, copy preparation and processing, page makeup, mechanics, printing processes, magazine imposition. Workshop atmospheres.

HU 142 Writing Operations and Maintenance Manuals 3:0:3
Preparation of industrial and military technical instruction manuals covering all phases of operation and maintenance of various kinds of equipment discussed. How to write these documents according to government specifications. Compilation of technical information for manuals and use with graphics and tabular material (such as troubleshooting charts) in practical writing situations. Assembling of parts lists.

HU 150-151 Special Projects in Communications each 3:0:3
Independent work in an area of communications selected by student in consultation with instructor. For majors only.
HUMANITIES AND COMMUNICATIONS

HU 155 Special Topics in Journalism 3:0:3
Courses on special topics in journalism are offered from time to time by department staff or by visiting scholars. Specific titles and prerequisites are announced prior to registration. May be repeated for credit.

HU 160 Writing the News for TV and Radio 3:0:3
The special formats required for writing news for TV and radio. Rewriting of newspaper articles and wire copy in styles necessary for these formats. Practice in broadcasting news and writing newscasts under pressure. Prerequisites: HU 108 or permission of instructor.

HU 161 Writing and Producing Documentaries for Broadcast 3:0:3
Working in teams, students research, write and narrate documentary radio and television broadcasts on pressing social, economic, political, scientific and technological issues, with emphasis on local topics. Production as well as journalistic side of broadcasting. Study of classic models at the Museum of Broadcasting.

LITERATURE

Please note: HU 101 or HU 103 is a prerequisite for all courses in this section.

(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, the Bible and others.

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 and others.

HU 203 Literature of Western Civilization III* 3:0:3
Intellectual and cultural, moral and spiritual values of modern world in novels, drama, philosophy, poetry. Literature of Romantic revolt, Goethe, Dostoevski, Bronte, Baudelaire, Solzhenitsyn, American and European verse.

HU 211 English Literature from Beowulf to 1800* 3:0:3
English literature from Beowulf through Chaucer, Elizabethans and Jacobean to 1800.

HU 212 English Literature from 1800 to Present 3:0:3
English literature from Romantics 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 literary merits of scientific 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, Heiner Kipphart, James Watson, Kurt Vonnegut and Isaac Asimov.

HU 222 Shakespeare 3:0:3
Representative tragedies, comedies, histories. Cultural, social and literary influences. Textual problems, recent criticism, Elizabethan theatre.

HU 251 American Literature to 1880 3:0:3

HU 252 American Literature from 1880 to Present 3:0:3

HU 258 American Thought* 3:0:3
Background, development and dynamics of American thought. Protest 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 262 Contemporary American Novel 3:0:3
Contemporary American novel as affirmative expression of the human situation. Technical and philosophical analyses of such writers as Galding, Salinger, Updike, Roth, Vonnegut, Clarke, Bell and others.

HU 264 The Short Story 3:0:3
Themes, structure, techniques of short stories by writers as diverse in style and philosophy as Chekhov, Twain, O. Henry, Mansfield, Larcher, Faulkner, Thurber and Hemingway.

HU 272 Contemporary American Poetry* 3:0:3
Contemporary American poetry as affirmative expression of the human situation. Technical and philosophical analyses of recent writers.

HU 281 Comedy 3:0:3
Nature and uses of humor as viewed by playwrights, psychologists, philosophers. Theories of comedy from Aristotle to Freud. Plays from Aristophanes and Moliere to Giraudoux and Shaw. Humor from Tarleton to Chaplin and Benchley.

HU 283 Modern American Drama* 3:0:3
Technical and philosophical analyses of O'Neill, Miller, Anderson, Heiman, Williams, Inge, Albee and others. Some contemporary American films may be included.

HU 291 Short Fiction 3:0:3
Major writers of the novella (long short story). Study of the relationship between literature and ideas in such writers as Saul Bellow, Albert Camus, Joseph Conrad, Ernest Hemingway, Franz Kafka, Thomas Mann, Alexander Solzhenitsyn, Nathaniel West. Class discus­sions, cinematic presentations of some works and theatre visits are integral to 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. Middle English 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 discussions of selected philosophical texts.

HU 344 Introduction to Logic 3:0:3
Principles and problems in syllogistic and propositional logic. Introduction to first order predicate logic. Some discussion of the history of logic, informal fallacies and relations between logic and language.

HU 345 Advanced Logic 3:0:3
Review of propositional logic, followed by an extended study of first order predicate logic. Examination of metamathematical and philosophical issues associated with formal systems. Introduction to higher order logic, semantics and modal logic. Prerequisite: HU 344 or equivalent.

HU 346 Ethical Theories 3:0:3
A study of one or more major ethical theories. The nature of human action, distinctions between good and bad, virtuous, sources of obligation, freedom of action, human valuation and conscience.

HU 347 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 will be made of case studies of various ethical problems as well as some classic ethical texts.

Also listed under LA 140.

HU 348 Great Philosophers I 3:0:3
Selected works of such philosophers as Plato, Aristotle, the Stoics, neo-Platonists, St. Augustine, Maimonides, St. Thomas Aquinas.

HU 349 Great Philosophers II 3:0:3
Philosophy from the Renaissance to the 19th century, emphasizing the rationalist tradition (Descartes, Spinoza, Leibniz), the empiricist tradition (Bacon, Locke, Hume) and Kant.

HU 352 Philosophy of Science 3:0:3
Central problems in theories 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.

HU 353 Philosophy of Technology 3:0:3
The nature and meaning of human making and using activities, examined by means of a critical reading of various conceptual, anthropological, ethical-political and metaphysical-epistemological studies.

HU 354 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 in the thoughts of selected political philosophers.

HU 355 World Religions 3:0:3
Fundamental beliefs and practices of the major world religions: Hinduism, Buddhism, Confucianism, Taoism, Judaism, Christianity, and Islam. Readings in religious texts complemented by audiovisual presentations.

HU 356 Philosophy of Religion 3:0:3
An examination of some of the key issues in understanding religion: the nature of religion and religious experience, relationships between faith and reason; arguments for and against the existence of God; problems of human destiny, death, immortality, religious language and pluralism in religion.

HU 365 Science, Technology and Religion 3:0:3
The implications of science and technology for religion, and of religion for science and technology. Does scientific cosmology support or undermine religious beliefs? Does the scientific method influence the interpretation of religious texts? What is the religious response to moral issues raised by technology? Is religion responsible for the development of Western technology?

MUSIC AND FINE ARTS

HU 371 Understanding of Music 3:0:3
Active, intelligent listening to masterpieces of Western music from its origins through Bach, Beethoven, and Brahms. Major musical forms: concerto grosso, fugue, sonata, symphony, concerto, music drama, tone poem. Analysis of orchestra scores. Parallel trends in other arts: the changes in the social roles of music.

HU 375 Modern Music 3:0:3
Music from 1820 to present: Wagner, Strauss, Mahler, Debussy, Stravinsky, Ives, Schoenberg, Berg, Weber, Varése. Revolt against romanticism; breakdown of traditional tonal-harmonic system. Polyrhythm, polytonality, pantonality, melodic fragmentation, aleatory and electronic music as expressions of the 20th century Jazz, modern popular music and music of other cultures.

HU 382 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.

HU 383 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 tectonic forms to express contemporary civilization.

HU 388 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 modes of thinking and feeling.

SPECIAL TOPICS

The following special topics courses are offered from time to time by the staff of the department or by visiting scholars. Specific titles and prerequisites are announced before registration. May be repeated for credit.

HU 300 Special Topics in Humanities 3:0:3
HU 301 Special Topics in Literature 3:0:3
HU 302 Special Topics in Philosophy 3:0:3

MODERN LANGUAGES

GERMAN

ML 111 German I: Foundation Course 3:0:3
For students with no previous training in German. Audiolinguistic techniques used to develop proficiency in reading, comprehension, speaking. Early practice in reading original German prose and representative poems.

ML 112 German II 3:0:3
Continuation of foundation provided by course ML 111. Reading of original German prose; selections from Hesse, Kastner, Zweig and others. Prerequisite: ML 111 or equivalent.
HUMANITIES AND COMMUNICATIONS

ML 113 German III: Readings in German Literature Since 1800 3:0:3
Reading and discussion of prose, lyric poetry and drama to acquaint students 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.

ML 114 German IV 3:0:3
Continued reading of significant German writing with critical and aesthetic evaluation. Also selected reading in philosophical and scientific subjects. Practice in conversation. Prerequisite: ML 113 or equivalent.

ML 115 Conversation and Composition* 3:0:3
Spoken German with particular attention to idiomatic expressions; compositions with training in syntax and style. Prerequisite: ML 114 or equivalent.

ML 121 Scientific German I* 3:0:3
Introductory course for students who wish to acquire facility in translation of scientific material from German into English. Fundamentals of grammar, problems of syntax and idiom, with emphasis on scientific terminology. May not be offered in fulfillment of any language sequence or as a humanities elective.

ML 122 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.

ML 213 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.

ML 214 Contemporary German Literature* 3:0:3
20th-century German writers and literary movements. Lectures, readings, reports. Prerequisite: ML 114 or equivalent.

ML 215 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 implication. Consideration of Goethe's contribution to science. Prerequisite: ML 215.

ML 217-218 German Thought from Kant to Present I, II* each 3:0:3
Significant intellectual currents in writings of philosophers, scientists, poets, social critics. First semester from Kant to Nietzsche, second semester 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, social and economic structures. Prerequisite: ML 114 or equivalent.

FRENCH

ML 131 French I: Foundation Course 3:0:3
For students with no previous training in French. Audiolingual techniques used to develop proficiency in reading, comprehension, speaking. Early practice in reading original French prose and representative poems.

ML 132 French II 3:0:3
Continuation of foundation provided by ML 131. Reading of modern French prose and poetry. Prerequisite: ML 131 or equivalent.

ML 133 French III: Readings in French Literature Since 1800 3:0:3
Reading and discussion of prose, lyric poetry, drama to acquaint students 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 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; compositions 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 on Rabelais, Montaigne, Descartes, Pascal, Rousseau, Voltaire, the Encyclopedia. Second semester on Joseph de Maistre, Balzac, Michelet, Comte, Taine, Renan, Bergson, Sartre, Maritain, Levi-Strauss. Readings in French and English. Prerequisite: ML 134 or equivalent.

ML 237 Contemporary French Literature* 3:0:3
Varied currents of 20th-century literature 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 with no previous training in Russian. Audiolingual techniques used to develop proficiency in reading, comprehension, speaking. Early practice in reading original Russian prose and representative poems.

ML 152 Russian II* 3:0:3
Continuation of foundation provided by ML 151. Reading of Russian prose and poetry. Prerequisite: ML 151 or equivalent.

ML 153 Russian III: Readings in 19th-Century Russian Literature* 3:0:3
Reading and discussion of prose, lyric poetry, drama to acquaint students 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 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
Reading of Soviet prose and poetry. Simultaneous study of USSR's geographic, political, cultural status. All readings in Russian. Prerequisite: ML 154 or equivalent.
SPANISH

ML 161 Spanish I: Foundation Course 3:0:3
For students with no previous training in Spanish. Audiolingual techniques used to develop proficiency in reading, comprehension, speaking. Early practice in reading original Spanish prose and representative poems.

ML 162 Spanish II 3:0:3
Continuation of foundation provided by ML 161. Reading of modern Spanish prose and poetry. Prerequisite: ML 161 or equivalent.

ML 163 Spanish III: Readings in Spanish Literature Since 1800 3:0:3
Reading and discussion of prose, lyric poetry, drama to acquaint students 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 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
Intellectual and literary aspects of Hispanic-American civilization touching on historical, sociological, political, economic backgrounds. Readings in Spanish. Discussion of contemporary life and practice in speaking Spanish. Prerequisite: ML 164 or equivalent.

LITERATURE IN TRANSLATION

Please note: HU 101 or HU 103 is a prerequisite for courses in this section.

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. One complete work by each of the following novelists: Hermann Hesse, Franz Kafka, Thomas Mann, Heinrich Böll, Gunter Grass. Course work directed toward understanding these men and their works within their own varying social and cultural settings. Students are 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. One complete work of each writer. Students are encouraged to pursue interests in individual authors.

ML 313 Currents of Unrest in 20th Century: Russian Literature (in English translation)* 3:0:3
Modern Russian literature in post-revolutionary political and social setting. Sholokhov, Pasternak, Solzhenitsyn. Students are encouraged to pursue interests in individual authors.

ML 318 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

Please note: HU 101 or HU 103 is a prerequisite for courses in this section.

ML 381 Language and Society* 3:0:3
Nature and social functions of language. Its key properties as contrasted with animal communication. Theories on origin of speech, vocal organs. Introduction to phonetics and phonemics. History of writing. Phonetic changes. Survey of world’s languages. Etymology, semantics, semantic shifts. Open to undergraduate and graduate students. May be taken as humanities elective.

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’s languages and 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
Descriptive and historical linguistics. Detailed analysis of topics in syntax, phonemic problems in study of English and foreign languages, graphemics, linguistic phylogeny and phylogenetic changes. Generative-transformational, mathematical and computational linguistics. Machine translation. May be taken as humanities elective. Prerequisite: ML 381 or ML 382 or equivalent.

INTERDISCIPLINARY STUDIES

IS 140 Language and Communication 3:0:3
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
The changing pattern of nationalism in the United States and the changing self-definition of the American in response to forces from within 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.

HUMANITIES AND COMMUNICATIONS
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GRADUATE COURSES

SCIENCE, TECHNICAL AND FINANCIAL WRITING AND JOURNALISM

JW 510  Technical Writing about Digital Electronics I  2:0:3
Introduction to digital circuits, symbols, truth tables, Boolean Equations of logic elements. Detailed functional discussions of the application of logic elements in such functional combinations as adders, comparators, decoders, and signal controllers.

JW 520  Technical Writing about Digital Electronics II  2½:0:3
Development of an understanding of the practical application of logic gates and flip-flops. Sequential circuits such as up counter, down counters, shift registers, and parallel to serial converters. Students learn to recognize circuits, develop timing diagrams, and write functional descriptions.

JW 600  Introduction to Specialized Journalism  2½:0:3
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  2½:0:3
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  2½:0:3
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, financial information, technical competency of the company to perform the task and key personnel. 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  2½:0:3
Emphasis on spot-news reporting and the Sunday-supplement feature aimed at a general newspaper audience. The longer interpretive 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-article 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  Media 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 media 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 as well. Major considerations are content of the talk, the speaker’s demeanor, use of visual aids, delivery of the paper (diction, 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 these must be taken into account in news writing. Students will use video and audio technology in the course.

JW 608  Introduction to Documentation  2½:0:3
An introduction to the field of technical documentation in general and to computer documentation in particular. Includes a brief history of documentation and management needs in the documentation area, particularly techniques, production and core studies.

JW 609  Computer Documentation  2½:0:3
An overview and introduction to computer systems and software documentation. Topics include the history of computer documentation, market trends in the field, role of the documentation specialist, basic concepts and techniques, types of manuals, planning and management documentation. Prerequisite: one technical writing course and MG 602: Computers in Management.

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 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.

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JW 622 Writing Copy for Industrial Public Relations 2 ½:0:3
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 staff 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 2 ½:0:3
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 2 ½:0:3
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. Preparation to preparing copy for the shorter product-promotion bulletins, 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 2 ½:0:3
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 2 ½:0:3
The special considerations, responsibilities and problems of 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 2 ½:0:3
Course is geared to preparing students for expanding opportunities in writing copy for pharmaceutical and drug companies. Intensive practice in writing new-product data sheets, bulletins and other technical literature generally used by “detail” men; research reports, progress reports and other technical papers based on information supplied by instructor and gathered on trips to local pharmaceutical companies; technical speeches; advertising and public relations copy. A major paper will be assigned as a term project.

JW 628 Writing Industrial Advertising Copy 2 ½:0:3
Covers the objectives of industrial and technical advertising and how to achieve them through the three basic ingredients of the magazine ad: copy, artwork and layout. Emphasis is on the principles of writing effective copy and heads, the process of media selection for a given ad (product promotion, institutional), 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 629 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 these 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 library 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 607, which will provide some background in video and media writing.

JW 641 Graphics Workshop 2 ½:0:3
A workshop devoted to the actual production of technical graphics — charts, graphs, newsletters, etc. Prerequisite: JW 604 or equivalent.
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JW 701 Special Project in Professional Writing 2 1/2:0:3
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 1/2:0:3
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: by placement test as required by graduate departments or by student choice. Course may be taken more than once. Some sections also provide instruction in writing correct English.

HU 605† Report Writing 2 1/2:0:3

HU 622† Seminar in Shakespeare* 2 1/2:0:3
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 639† Seminar in American Thought* 2 1/2:0:3
Basic American attitudes and concepts as revealed culturally—literature, films, periodicals, comics, art—with emphasis on development of American mythology. Prerequisites: HU 251, HU 252, HU 262 or equivalent.

HU 652† Seminar in Philosophy of Science* 2 1/2:0:3
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 1/2:0:3
Central concepts of social and political thought, freedom, law, justice, rights, democracy, property in writings of historical and contemporary philosophers. Emphasis on various interpretations of these concepts found in currently influential and conflicting sociopolitical ideologies.

HU 667† Seminar in English Language* 2 1/2:0:3

MODERN LANGUAGES

ML 611† German for Research* 2 1/2:0:3
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 characteristic 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* 2 1/2:0:3
Introductory course for students who wish to acquire facility in translation of scientific material from Russian into English. Fundamentals of grammar, problems of syntax and idioms, with emphasis on scientific terminology. Not for thorough formal knowledge of the language. May not be offered in fulfillment of language requirement.

ML 656† Russian for Research II* 2 1/2:0:3
Continuation of ML 655. Reading material from periodicals and technical journals covering fields of engineering and science. Prerequisite: ML 655 or equivalent.

FACULTY

Duane DeVries, Associate Professor of English and Head of Department
B.A., Kalamazoo College; M.A., Ph.D., Michigan State University
Dickens, the nineteenth-century English novel, expository writing

Victor Bobetsky, Professor of Modern Languages
B.S., M.A., Columbia University
German language and literature

Donald Hockney, Professor of Philosophy of Science
B.A., McMaster University; Ph.D., Cornell University
Philosophy of science, philosophy of language

Bernard Rechtschaffen, Professor of Modern Languages
B.S., M.A., Ph.D., New York University
Comparative literature, science and literature

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

Sylvia Kasey Marks, Associate Professor of English
B.A., M.A., University of Michigan; Ph.D., Princeton University
Samuel Richardson, the eighteenth-century English novel, public speaking

Carl Mitcham, Associate Professor of Philosophy and Director of the Philosophy and Technology Studies Center
B.A., M.A., University of Colorado
Philosophy of technology

Lowell L. Scheiner, Associate Professor of Humanities and Communications
B.A., City College, City University of New York; M.A., Columbia University; M.S., Columbia University (Graduate School of Journalism)
Technical writing, journalism
Wolhee Choe, Assistant Professor of English
B.A., Adephi University; M.A., Ph.D., City University of New York
*Nineteenth-century English literature, literary theory, English as a second language

Jene Robinett, Assistant Professor of Humanities and Communications
B.A., Goshen College; M.A., Ph.D., University of Notre Dame
*Software documentation, twentieth-century poetry

ADJUNCT FACULTY

Barbara Bartholomew, Adjunct Instructor of Communications
B.A., San Diego State University; M.S., Polytechnic Institute of New York
(Specialized Journalism)

Edward Bell, Adjunct Instructor of Communications
B.A., City College, City University of New York

Jerry E. Bishop, Adjunct Instructor of Communications
B.A., University of Texas

Gerard Cardillo, Adjunct Instructor of Communications

Allen M. Cobrin, Adjunct Instructor of Communications
B.A., City College, City University of New York; M.A., Columbia University

Frederick Courtney, Adjunct Assistant Professor 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., State University of New York at Stony Brook

Robert J. Frail, Adjunct Assistant Professor of English
B.S., Manhattan College; B.A., B.Phil., Ph.D., Columbia University

Peter Z. Grossman, Adjunct Associate Professor of Humanities and Communications
M.A., M.F.A., Columbia University

Robert L. Guenther, Adjunct Instructor of Communications
B.A., Journalism, University of Missouri

Eric Jay, Adjunct Instructor of English
B.A., Amherst College

Dawn Houghton-Alico, Adjunct Instructor of Communications
B.A., Cedar Crest College

Eric Katz, Adjunct Assistant Professor of Philosophy
B.A., Yale University; M.A., Ph.D., Boston University

Dianne Kohl, Adjunct instructor of English
B.A., Queens College, City University of New York; M.A., State University of New York at Stony Brook

HUMANITIES AND COMMUNICATIONS

Lenore Kuhn, Adjunct Instructor of Communications
B.A., Hunter College; M.A., University of Arizona; M.S., Polytechnic University

Linda Lerner, Adjunct instructor of English
B.A., M.A., Brooklyn College, City University of New York

Carol Lippman, Adjunct Assistant Professor of English
B.A., State University of New York at Binghamton; Ph.D., University of Massachussetts

Dolores Massari, Adjunct Instructor of Communications
B.S., Fordham University

Isobel Mendelson, Adjunct Instructor of English
B.A., Syracuse University

Carol Lynn Moder, Adjunct Assistant Professor of English
B.Á., State University of New York at Geneseo; M.A., Ph.D., State University of New York at Buffalo

Alan M. Nadler, Adjunct Instructor of English
B.A., Queens College, City University of New York; M.A.T., University of Iowa; M.F.A., Columbia University

Peter E. S. Nichols, Adjunct instructor of English
B.A., Beloit College; M.A., City College, City University of New York

Mary Orovian, Adjunct Instructor of English
B.A., University of Southern California; M.A., New York University

Hans Ostermann, Adjunct Instructor of Modern Language
B.A., M.A., Hotstra University

Bonnie J. Phillips, Adjunct Instructor of English
B.A., Calvin College; M.A., Boston College

Larry Reibstein, Adjunct Instructor of Communications
M.A., Ohio State University

Colleen M. Sandford, Adjunct Assistant Professor of English
B.A., Washburn University; M.A., Ph.D., University of Illinois

Valerie Seyers, Adjunct Instructor of English
B.A., Fordham University; M.F.A., Columbia University

Wolfgang Schirmacher, Visiting Adjunct Assistant Professor of Philosophy
Ph.D., University of Hamburg (Germany)

Nenci Milestein Shapiro, Adjunct Instructor of Art
B.A., M.A., State University of New York at Binghamton

Kathleen R. Slowik, Adjunct instructor of English
B.A., Utica College of Syracuse University; M.A., Columbia University

David Soracchi, Adjunct Instructor of English
B.A., St. John’s University; M.A., San Francisco State University

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HUMANITIES AND COMMUNICATIONS

Walter Stiller, Adjunct Instructor of English
M.Phil., City University of New York

James E. Tourtelott, Jr., Adjunct Assistant Professor of English
B.A., St. John's College (Maryland); M.A., Ph.D., State University of New York at Stony Brook

Roberta L. Ventsias, Adjunct Instructor of English
B.A., M.F.A., Brooklyn College, City University of New York

Michael Waldholz, Adjunct Instructor of Communications
M.A.T., University of Pittsburgh

EMERITUS FACULTY

John G. Cavanna, Professor Emeritus
Ph.D., University of Minnesota

Clifford Osborne, Professor Emeritus
M.A., University of Denver
IMAGING SCIENCES AND ENGINEERING

Imaging sciences and engineering (IS & E) is an interdisciplinary subject which concerns all aspects of the acquisition, communication, display, recording and understanding of pictorial information. It is the basis of world-wide industries, which include photography, graphic arts and television as well as newer areas such as remote sensing, computer graphics, and digital imaging.

Until now, imaging has been taught as a component of other disciplines: optics as part of physics, image processing under electrical engineering, photoactive materials in chemistry. Now there has emerged the new discipline of Imaging Sciences and Engineering, to deal comprehensively and in an integrated fashion with the needs of this industry. The Institute of Imaging Sciences, founded at Polytechnic in 1982, offers a graduate program in these disciplines which provides the intellectual foundation for all imaging technologies.

Drawing on faculty from five departments, the Institute conducts a variety of projects in image processing, communications, optics and devices, and photoactive materials. Its educational program is centered on the Master of Science degree in Imaging Sciences and Engineering.

THE GRADUATE PROGRAM

The preferred background for students entering the graduate program of IS & E is a bachelor's degree in Electrical Engineering from an ABET-accredited institution. Alternatively, a bachelor's degree in computer science, physics, mathematics or chemistry is suitable. Students with deficiencies in specific areas, particularly in mathematics, may be required to take one or more preparatory courses before entering the Imaging Sciences program. Professional experience in areas relating to Imaging is given strong consideration during admission.

All courses in the curriculum are offered in the evening for the convenience of working professionals. Curriculum may be pursued either part-time or full-time, with normal completion in 3 years or 1 ½ years respectively. All courses are open and may be taken under non-degree status. Candidates for the Masters of Science degree in IS & E must plan their program with reference to the list of required courses.

Apart from the academic courses listed in the table, the Institute organizes a series of Imaging Colloquia where well-known experts offer seminars on a variety of Imaging subjects. The Colloquia are open to everyone and they do not carry academic credit, but they provide an opportunity for students and faculty to listen to and meet imaging experts from industry as well as from other universities.

Requirements for Master of Science Degree in Imaging Sciences and Engineering

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Courses</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM 602</td>
<td>Optics</td>
<td>3</td>
</tr>
<tr>
<td>IM 603</td>
<td>Vision, Color</td>
<td>3</td>
</tr>
<tr>
<td>IM 604</td>
<td>Image Processing Principles I: Deterministic Signals</td>
<td>3</td>
</tr>
<tr>
<td>IM 605</td>
<td>Image Processing Principles II: Stochastic Signals, Information Theory</td>
<td>3</td>
</tr>
<tr>
<td>IM 606</td>
<td>Imaging Laboratory</td>
<td>3</td>
</tr>
<tr>
<td>IM 701</td>
<td>Image Analysis</td>
<td>1½</td>
</tr>
<tr>
<td>IM 702</td>
<td>Image Processing Laboratory</td>
<td>1½</td>
</tr>
<tr>
<td>IM 703</td>
<td>Chemical and Physical Image Recording: Graphic Arts</td>
<td>3</td>
</tr>
<tr>
<td>IM 704</td>
<td>Electronic Imaging</td>
<td>3</td>
</tr>
</tbody>
</table>

Having completed the required courses the student registers for a Masters Project with his adviser. He also registers at that time for two elective courses to support that project.

Electives (Two from list)

<table>
<thead>
<tr>
<th>No.</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM 730</td>
<td>Medical Imaging</td>
<td>3</td>
</tr>
<tr>
<td>IM 731</td>
<td>Pattern Recognition, Principles and Methods</td>
<td>3</td>
</tr>
<tr>
<td>CS 651</td>
<td>Computer Graphics and Imaging Processing</td>
<td>3</td>
</tr>
<tr>
<td>EL 635</td>
<td>Principles of Communication Networks</td>
<td>3</td>
</tr>
<tr>
<td>MT 705</td>
<td>Semiconductor Technology</td>
<td>3</td>
</tr>
<tr>
<td>EL 658</td>
<td>Fiber Optic Communications</td>
<td>3</td>
</tr>
<tr>
<td>IM 740, IM 741</td>
<td>Special Topics in Imaging</td>
<td>3</td>
</tr>
</tbody>
</table>

MS Project

<table>
<thead>
<tr>
<th>No.</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM 990</td>
<td>Project in Imaging Science</td>
<td>6</td>
</tr>
</tbody>
</table>

Total Credits (Required Courses, Two Electives, Project) 36

In order to qualify for the master of science degree, the student must obtain 36 credits. The MS project counts for 6 credits. All other courses, with the exception of IM 701 and 702, are 3 credit courses as shown in the course descriptions. It is possible to take courses separately on a non-degree basis. The academic credit accumulated by the special student will be counted towards the MS degree if later the student decides to complete the program for a degree. Some of our courses are accepted as electives in Electrical Engineering, Physics and Chemistry.
underlying recent developments in medical imaging are presented.

An introduction to the physics and information theoretical aspects of image recording; silver halide photography; other non-conventional imaging processes; microimaging, microlithography, radiation-sensitive materials, and photogrammetry.

IM 704, IM 741 Special Topics in Imaging 2½:0:3

Presentations, at intervals, of advanced or specialized topics in imaging science or technology. Projected subjects include integrated optics, graded index materials in imaging, holographic methods, microimaging, microlithography, radiation-sensitive materials, and photogrammetry.

IM 790, 991 Project in Imaging Science 5:0:0

Experimental and theoretical investigation of a problem in imaging science under the guidance of a faculty adviser. A comprehensive written report is required, to be submitted to the adviser one week before the last day of classes. Prerequisite: Degree status and project adviser’s approval.

FACULTY

Arnold Reiser, Course Director, Professor of Chemistry, Deputy Director, Institute of Imaging Sciences
Dr. Ing. (Prague); D. Sc. (London); formerly Head of Photochemistry Laboratory, Kodak, England; 1961 Henderson Medal of Royal Photographic Society

Irael Abramov, Professor of Psychology, Brooklyn College of CUNY: Professor of Psychophysics, Rockefeller University.
B.A., University College, London; Ph.D., Indiana University.

Stephen Arnold, professor of Physics
B.S., University of Toledo; Ph.D., City University of New York; Fellow, Alfred P. Sloan Foundation

Leo Beiser, Consultant in Laser Technology
B.S. and M.S. (Physics), Hofstra University
Formerly Director of Dennis Gabor Laboratory of CBS; Governor of Society of Photo-Optical Instrumentation Engineers

Leonard Bergstein, Professor of Electro-Optical Sciences.
Ph.D., Polytechnic Institute of New York

George R. Bird, Professor of Chemistry, Rutgers University.
B.A., M.A. and Ph.D., Harvard University.
Formerly head of Physical Chemistry Laboratory, Polaroid Corporation
Spectroscopy; fundamental photographic science

J. Warren Blaker, Consultant in Optics.
Ph.D., Massachusetts Institute of Technology.
Formerly Head of Physics Department, Vassar College.


Patrick T. Cahill, Professor of Physics, Professor of Radiology, Cornell University Medical School. B.S. and M.S., University of New Hampshire; Ph.D., Harvard University.

Philip Chu, Associate Professor, Mechanical Engineering. B.S., National Cheng Kung University (Taiwan); M.S., Auburn University; Ph.D., University of South Carolina.

Douglas A. Davids, Associate Professor of Electrophysics. B.S., M.S., Newark College of Engineering; Ph.D., John Hopkins University.

Bruce A. Garetz, Associate Professor of Physical Chemistry. B.A., Harvard University; Ph.D., Massachusetts Institute of Technology.


Irving Hirschberg, Director Technology Developments, Fairchild Weston Systems. B.E.E., Cornell University; M.S.E.E., Columbia University.

Aaron Kershenbaum, Associate Professor of Computer Science. B.S. and M.S., Polytechnic Institute of Brooklyn; Ph.D., Polytechnic Institute of New York.

Leonard Shaw, Professor and Head of Dept. of Electrical Engineering. B.S., University of Pennsylvania; M.S. and Ph.D., Stanford University.

Rodney Shaw, Physicist, Eastman Kodak Company. Ph.D., Cambridge University, Journal Award and 1976 Charles E. Ives Award of The Society of Photographic Scientists and Engineers (SPSE).

Richard Thorsen, Associate Professor of Mechanical and Aerospace Engineering. B.M.E., City College of New York; M.M.E. and Ph.D., New York University.

Dante C. Youla, Professor of Electrical Engineering. B.E.E., City College of New York; M.S., New York University; Member of the National Academy of Engineering.
INDUSTRIAL ENGINEERING

The Department of Transportation and Industrial Engineering offers programs in industrial engineering at the bachelor’s, master’s, engineer’s, and doctor’s levels.

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 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.”

Industrial engineers are asked 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. Industrial engineers solve specific problems and design new man-machine configurations. They make heavy use of computers, frequently employing heuristic rather than analytic approaches.

Industrial engineers 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 systems 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 industrial engineering.

These techniques are applied 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 their administration. While engineering and management are different fields, both require the ability to make decisions based on valid information.

LABORATORIES AND COMPUTING FACILITIES

The Department operates laboratories in the areas of work design and measurement, human factors, plant layout, robotics, automation, and noise measurement; these laboratories are equipped with the latest equipment. Besides direct experimentation, students engage in simulated experimentation and decision making using a broad range of computers.

In addition to the Polytechnic-wide computing facilities described elsewhere in this catalog, the Department maintains its own bank of APPLE and IBM-PC computers, as well as direct access and UNIX terminals connecting with the Polytechnic’s IB 4341 and DEC-11 computers. Students use existing software packages or they may write their own.

UNDERGRADUATE PROGRAM

The undergraduate program leads to the degree of bachelor of science in industrial engineering, which is recognized by the Accreditation Board for Engineering and Technology.

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 a flexible program of study in which students have 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 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 applications 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 all endeavors.

**Senior Project**

An important part of the program is the cap-stone senior design project course. In the senior year, students in small groups tackle a real-life problem under the guidance of a faculty advisor. The problems may be provided by industry or other outside sources, and may have a practicing industrial engineer as co-advisor. Oral and written reports help prepare the students for similar activities required in their professional lives.

**Graduate courses** may be taken as electives by qualified juniors and seniors with at least a B average, who obtain their advisers' approval. If the total number of credits exceeds those required for bachelor's degrees, 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 requirements for bachelor's degrees in two additional years of study. Assuming that a 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 on page .

**Evening Study**

Many of the courses in the industrial engineering program are available in the evening or late afternoon for the convenience of part-time students. Part-time students can usually finish the program in eight years, without summer work, by averaging eight and a half credits per semester. However, students can change loads readily to suit their educational needs, provided they do not violate prerequisite and Polytechnic time limits.

*Suggested Elective Sequences*

Students often seek guidance in using permitted electives to develop a meaningful sequence for concentration. Suggested groupings from which students 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>Group</th>
<th>Courses</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics:</td>
<td>MA 101, MA 102, MA 103, MA 104, MA 223, MA 224</td>
<td>20</td>
</tr>
<tr>
<td>Science:</td>
<td>CM 101, CM 102, CM 111, CM 112, CS 100, PH 101, PH 102, PH 103</td>
<td>18</td>
</tr>
<tr>
<td>Humanities:</td>
<td>HU 101, HU 200, SS 104, SS 189, SS 251, SS 252</td>
<td>18</td>
</tr>
<tr>
<td>Physical Ed:</td>
<td>PE 101, PE 102, PE 103, PE 104</td>
<td>0</td>
</tr>
<tr>
<td>Engineering:</td>
<td>AM 101, AM 115, CE 202, EE 370, EE 374, MT 301</td>
<td>16</td>
</tr>
<tr>
<td>Management:</td>
<td>MG 304</td>
<td>3</td>
</tr>
<tr>
<td>Electives:</td>
<td>Chosen by student in consultation with department adviser</td>
<td>24</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>136</strong></td>
</tr>
</tbody>
</table>

See footnotes on following page.
INDUSTRIAL ENGINEERING

Typical Course of Study for the Degree of Bachelor of Science in Industrial Engineering

A typical program sequence is shown below covering eight semesters. Students may rearrange courses and increase or decrease loads 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.

**Freshman Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
</tr>
<tr>
<td>CS 100 Intro. to Computer Progrmsg.</td>
<td>2</td>
</tr>
<tr>
<td>HU 101 Writing &amp; the Humanities</td>
<td>3</td>
</tr>
<tr>
<td>MA 101 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3</td>
</tr>
<tr>
<td>SS 251 Micro-Economics</td>
<td>3</td>
</tr>
<tr>
<td>PE 101 Physical Education I</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Sophomore Year**

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
</tr>
<tr>
<td>AM 101 Graphics</td>
<td>1</td>
</tr>
<tr>
<td>HU 200 Writing &amp; the Humanities II</td>
<td>3</td>
</tr>
<tr>
<td>MA 102 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>PH 102 Introductory Physics II</td>
<td>3½</td>
</tr>
<tr>
<td>SS 252 Macro-Economics</td>
<td>3</td>
</tr>
<tr>
<td>PE 102 Physical Education II</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

**Junior Year**

| **No.** | **Subject** | **Cl.** | **Lab.** | **Cr.** |
| AM 116 Engineering Mechanics I  | 2          | 0       | 2        |
| CM 101 General Chemistry I      | 2½         | 0       | 2½       |
| CM 111 General Chemistry Lab. I | 0          | 1½      | 2½       |
| IE 254 Intro. to Industrial Engineering | 0      | 1½      | 3        |
| MA 104 Appl. Differential Equ.   | 3          | 0       | 3        |
| PH 103 Introductory Physics III  | 2½         | 1½      | 3        |
| SS 104 Contemporary World History | 3         | 0       | 3        |
| PE 103 Physical Education III    | 0          | 2       | 0        |
| **Total**                        | **0**      | **0**   | **17**   |

**Senior Year**

| **No.** | **Subject** | **Cl.** | **Lab.** | **Cr.** |
| IE 305 Facility Planning & Design | 3          | 0       | 3        |
| IE 390 Project Laboratory II     | 3          | 0       | 3        |
| **Electives**                    | **3**      | **0**   | **9**    |
| **Total**                        | **3**      | **0**   | **12**   |

Total credits required for graduation: 136

---

1Students may substitute IS 140-141 for HU 200, SS 104. Students with strong mathematical background may substitute MA 111-114 for MA 104. Students may substitute CS 112 for CS 100; the extra credit may be counted as technical elective. Students may substitute AM 115 for AM 116-117.

2The 24 credits of electives are to be distributed as follows. All require adviser's approval.
   8 credits of industrial engineering courses
   3 credits of engineering science selected from courses below (excess credits count as technical electives): AM 201 Thermodynamics, AM 252 Dynamic System Response I
   14 credits of general electives
   CS 235 Switching Circuit & Digital Syst., MT 407 Transport Methods in Metallurgy, NU 301 Intro. to Nuclear Engineering, IE 306 Engineering Economy

3ROTC 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 and/or free electives.
MANUFACTURING ENGINEERING CONCENTRATION

In its beginning, the industrial engineering profession was devoted largely to manufacturing operations. Over the years, industrial engineers have been called upon to enlarge their expertise to include much wider ranges of applications, from hospital management to banking information systems. The consequent broadening of industrial engineering education led necessarily to a relative deemphasis of manufacturing engineering.

But today more than ever before, manufacturing enterprises must operate with heightened efficiency and precision to compete in the international market. In helping American industry, Polytechnic has developed a concentration to emphasize manufacturing in its industrial engineering program.

This manufacturing engineering concentration was prepared by an interdisciplinary committee, aided by a select industrial advisory group and an extensive national survey. The concentration is designed to educate students in productivity, computer-aided design and computer-aided manufacturing (CAD/CAM), robotics, factory automation and computer-integrated manufacturing (CIM).

All courses required for the standard degree are also required in the Manufacturing Engineering concentration.

The 24 credits of electives are satisfied as follows:

6 credits industrial engineering courses
IE 342 Robotics Applications (Term 8)
IE XXX Elective (Term 8)

3 credits manufacturing science
MT 407 Transport Methods in Metallurgy (Term 8)

3 credits technical elective
MT 417 Welding Metallurgy (Term 7)

6 credits humanities and social science
Selected in consultation with adviser (Term 8)

6 credits free elective
AM 331 Computational Methods in Computer-Aided Design (Term 6)
AM 332 Computer Graphics in CAD (Term 7)

TRANSPORTATION CONCENTRATION

The academic preparation of industrial engineers is a very good basis for graduate study and careers in transportation planning and engineering. These fields, as described under the Transportation heading of the catalog, are heavily indebted to industrial engineering methodology as presented in the engineering economics, human factors, system simulation, facility planning, work design, statistical quality control, and operations research modelling courses.

Polytechnic's faculty and research programs in transportation provide unique opportunities for industrial engineering students to obtain a grounding in these fields. To this end, a transportation concentration is offered wherein students choose appropriate elective courses, as shown in the table below, and select transportation projects for the senior IE 389-390 laboratory courses.

All courses required for the standard degree are also required in the Transportation concentration. The 24 credits of electives are satisfied as follows:

6 credits of industrial engineering courses
IE 350 Logistics
IE XXX Elective

3 credits engineering science
AM 201, AM 252, CE 222, CS 236, MT 407, or NU 301

3 credits technical elective
TR 361 Transportation Demand Models

6 credits humanities and social science
INDUSTRIAL ENGINEERING

Selected in consultation with adviser
6 credits of free electives
TR 360 Traffic Planning and Operations
TR 362 Public Transportation

GRADUATE STUDIES

The department offers graduate programs in industrial engineering leading to degrees of master of science in industrial engineering, engineer in industrial engineering and doctor of philosophy.

Students may specialize in information science, system simulation, quality control, experimental design, man-machine systems, social systems dynamics, production engineering, production and inventory models, reliability and maintainability, among other areas. Certificate programs are available for more limited graduate studies 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. Common to all our students is the desire to develop techniques for problem-solving and decision-making in a technical world.

MASTER OF SCIENCE DEGREE

The general requirements for 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. A student not meeting these requirements is considered for admission on an individual basis, and may be admitted subject to the completion of appropriate undergraduate courses to remove deficiencies in preparation.

Knowledge of computer programming in a high level language, such as FORTRAN or PL/I, is assumed. Students without this knowledge must take IE 531 without credit.

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 Degrees of Master of Science in Industrial Engineering

A. Basic Required Courses

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 502, MG 505, and MG 630.

- IE 600 Engineering Economy
- IE 606 Work Design & Measurement
- MA 561 Elements of Probability
- IE 608 Statistics

B. Required Courses

- IE 611 Statistical Quality Control
- IE 619 Production Planning & Control
- IE 621 Facility Planning & Design

C. Major Electives: (Select four courses)

- IE 614 Modeling of Social Systems
- IE 680 System Simulation
- IE 846 Urban Systems Analysis

- IE 765 Human Factors in Engrg. Design
- IE 775 Industrial Safety Engineering

- IE 776 Manufacturing Resource Planning
- IE 778 Advanced Production Planning

- IE 777 Manufacturing Improvement Curves
- IE 779 Advanced Work Systems Design

- IE 852 Applied Regression & ANOVA
- IE 853 Design of Experiments

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 required of doctoral students. General requirements for the engineer degree are stated in this catalog under "Degree Requirements." Detailed requirements for this degree are given here.

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 bachelor's degree or 36 units beyond 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.

*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 the course. Up to three group A courses actually taken may be credited toward the degree requirements, if more than three must be taken, degree requirements are increased accordingly.

*Only one of each bracketed set of courses is counted in the group in which it is listed, the other courses may be counted under group D.

*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 disciplines.

*Certain introductory courses will be waived if a student takes specified advanced courses, for which full credits will be given. For IE 627; IE 631 and IE 632. For IE 628; IE 650.
presentation before a faculty committee. The project may be waived by the guidance committee for professionally mature candidates who have previously completed work in their major areas judged to be of exceptional caliber, and for those students who have completed suitable master's theses or projects.

Requirements for 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, 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 618 Inventory Models
   IE 631 Linear Programming
   IE 650 Queuing Systems
   IE 778 Advanced Production Planning
   IE 779 Advanced Work Systems Design
F. Project: IE 998 (unless waived by adviser) 6-12 units
G. Other relevant electives 0-21 units

Minimum total 36

DOCTOR OF PHILOSOPHY DEGREE

The department offers a program leading to the degree of doctor of philosophy in operations research and industrial engineering. Students concentrating in industrial engineering must have bachelor's degrees in engineering disciplines from an accredited institution. 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 upon passing the program's qualifying examination. This consists of the Part I preliminary written examination and the Part II major field written examination; an oral examination may also be required. An examination is required in one foreign language ordinarily French, German or Russian.

The doctoral program requires a minimum of 90 units beyond 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 selects a thesis adviser and prepares a formal proposal for the dissertation research. A thesis committee will be appointed to judge the merits of the proposed research. After approval of this proposal, the doctoral candidate registers 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 accordance 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 student is issued a certificate. Students who later are admitted to study for a master's degree are usually able to apply all certificate courses toward the master's degree.

If students have taken the equivalent of any required courses as undergraduates or more than one as graduate students, then substitute courses must be selected in consultation with the adviser. Additional information may be obtained from the department.

The certificate programs are shown below. Additional certificates are shown in the Operations Research section of this catalog.

Basic Industrial Engineering
IE 600 Engineering Economy
IE 606 Work Design & Measurement
MA 561 Elements of Probability
IE 608 Statistics

Advanced Industrial Engineering
IE 611 Statistical Quality Control
IE 619 Production Planning & Control
IE 621 Facility Planning & Design
   One of the following:
   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
   One of the following:
   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
   One of the following:
   IE 671 Business & Economic Forecasting
   IE 680 System Simulation I
   IE 778 Advanced Production Planning
INDUSTRIAL ENGINEERING

UNDERGRADUATE COURSES

Note: Junior or senior standing is required for all undergraduate IE courses except IE 254.

IE 254 Introduction to Industrial Engineering, with Computer Applications 3:0:3
Basic principles of industrial and manufacturing engineering. Introduction to work design, manufacturing processes, inventories, and modeling in industrial engineering. Extensive use of spreadsheets, data bases and IE packages on PCs. Use of PC as word processor for reports.

IE 300 Engineering Economy 3:0:3

IE 302 Legal and Ethical Responsibilities of Engineers* 3:0:3
Responsibilities of engineers in design, operation and maintenance. Liabilities as brought out in court cases. Moral and ethical decision making, tradeoffs, and cost-benefit analysis in deciding for more safety versus more reliability, speed, efficiency or profit. Specific areas of concern include safety, health, and ethical dilemmas in the workplace, the products and services produced therein, the environmental fallout, and the operation of engineered systems for transport, communications, the home and other institutions of modern society. Prerequisite: junior standing.

IE 306 Work Design and Measurement 2:1.5:1.5
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. Prerequisite: junior standing.

IE 311 Statistical Quality Control 3:0:3
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, AOQL, AQL, and LQ of sampling plans, military sampling plans. Introduction to variable sampling plans. Prerequisite: MA 224.

IE 314 Simulation of Continuous Systems 3:0:3
Modeling and simulation of high order engineering, physical, managerial and social systems. Linear and non-linear models as interrelated positive and negative loops with emphasis on structure, feedback and delays. Exploration of various control algorithms as related to quickness of response and avoidance or alleviation of oscillation, using DYNAMO. Applications to manufacturing, transportation and social systems. Prerequisite: Knowledge of calculus and 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 probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Other topics include network development, computer adaptation, progress reports and project monitoring. Prerequisite: Knowledge of computer programming and junior standing.

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 problems 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 Manufacturing Processes 3:0:3

IE 341 Logistics* 3:0:3
Analysis of logistic problems and procedures applied to inventory control, materials handling systems, packaging, warehousing, transportation, facility location, information/communications, and customer service. Cost tradeoffs between the various components in optimization of the total logistics system. Logistics systems design and productivity measures. Business and military cases and applications. Prerequisite: IE 328.

IE 342 Robotics Applications* 2:1.5:1.5
Applied robotics and integration of robots into manufacturing processes. The course will cover robotic work space design and selection of robot types to suit each phase of industrial engineering. Laboratory experiments will include construction and use of robots and scaled models. Plant visits, field trips and case studies. Prerequisite: Junior standing.

IE 346 Operational Design of Public Systems* 3:0:3
Description, analysis and optimization of public systems. Population, economy, resource allocation, land use, transportation networks and facility location. Case studies of pollution control, criminal justice systems, library management, fire fighting strategies and public health. Prerequisites: IE 327, IE 328 and senior standing.

IE 350 Logistics* 3:0:3
Analysis of logistic problems and procedures applied to inventory control, materials handling systems, packaging, warehousing, transportation, facility location, information/communications, and customer service. Cost tradeoffs between the various components in optimization of the total logistics system. Logistics systems design and productivity measures. Business and military cases and applications. Prerequisite: IE 328.

IE 351 Human Factors in Engineering Design 2:1.5:1.5
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 and junior standing.
IE 375  Industrial Safety Engineering*  3:0:3
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, detection and control of hazards. Prerequisite: junior standing.

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 costs, 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, variances 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 and junior standing.

IE 389–390  Project Laboratory I, II  3:0:3
IE 389—credit arranged
Independent project combining elements of theory, experimentation, design and construction used to learn 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 student’s exchange of ideas and methods, and to enhance each student’s abilities in oral and written communication in engineering endeavors. Prerequisite: senior standing.

IE 391–392  Selected Topics in Industrial Engineering and Operations Research I, II  3:0:3
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  3:0:3
Each 3 credits
Individual reading of selected papers and current literature in specialized areas of study, guided by faculty member. Prerequisite: approval of adviser, 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  credit arranged
Independent work undertaken by qualified honors students in industrial engineering or operations research under faculty guidance. Prerequisites: senior standing and adviser’s approval.

GRADUATE COURSES

IE 531  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. Flowcharting. 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 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, tangible factors. (Not open to students who have taken IE 306.)

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 time studies. (Not open to students who have taken IE 306.)

IE 606  Statistics  2:0:3
Estimation, confidence limits, tests of hypothesis, regression analysis. Applications to engineering problems. (Not open to students who have taken MA 224.) Prerequisite: MA 561.
Also listed under MA 562

IE 611  Statistical Quality Control  2:0:3
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, AOQL, AQL, and LQ of sampling plans, military sampling plans, introduction to variables sampling plans. (Not open to students who have taken IE 311.) Prerequisite: IE 608.

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, non-normal variables sampling plans, treatment of outliers in industrial data. Prerequisite: IE 611.

IE 614  Modeling of Social and Managerial Systems*  2:0:3
This course introduces the student to general systems theory as it applies to managerial and social phenomena. Systems are viewed as related 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, and areas related to their individual interest.
Also listed under MG 714

IE 618  Inventory Models*  2:0:3
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 581 and either IE 627 or IE 631.

IE 619  Production Planning and Control  2:0:3
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 2 1/2:0:3 Network-planning techniques for project management and resource allocation. Emphasis on PERT, CPM, and probabilistic generalized networks. Heuristic methods 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* 2 1/2:0:3 Development of qualitative models for analysis of facility layout and location problems. Solutions by both mathematical optimization and heuristic algorithms. Location of single and multiple facilities in existing and new design layout. Other topics include computerized layout planning, materials handling systems, evaluation and improvement of facility productivity. (Not open to students who have taken IE 321.) Prerequisite: IE 606 or permission of instructor and either IE 627 or IE 631.

IE 624 Computer-Augmented Case Studies in Management Science* 2 1/2:0:3 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 and either IE 600 or permission of instructor.

IE 627 Operations Research: Deterministic Models 2 1/2:0:3 Development of mathematical models of solving decision problems of deterministic nature. Classical optimization, Lagrange multipliers, linear programming, transportation methods, network procedures, games. Dynamic programming. (Not open to students who have taken IE 327 or equivalent.) Prerequisite: Calculus.

IE 628 Operations Research: Stochastic Models 2 1/2:0:3 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: IE 616.

IE 631 Linear Programming 2 1/2:0:3 Theory and application of linear programming techniques. Simplex and revised simplex algorithms. Duality theory, dual simplex method, postoptimality analysis. Degeneracy, Transportation and assignment problems. Applications, problem formulation, computer solutions. Prerequisite: MA 153. Also listed under MA 813


IE 633 Integer Programming* 2 1/2:0:3 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* 2 1/2:0:3 Application of principle of optimality to solution of deterministic and stochastic systems as multistage decision processes. Relationship to variational methods, Nonlinear programming, Howard's algorithms. Applications, problem formulation, computational procedures. Prerequisites: MA 561 and either IE 627 or IE 631.


IE 642 Robotics Applications* 2 1/3: Applied robotics and integration of robots into manufacturing processes. The course will cover robotic work space design, selection of robot type for each phase of industrial engineering, flexible manufacturing and work cells. Laborotory experiments will include construction and use of robots and scaled models, Plant visits, case studies.

IE 645 Productivity Management* 2 1/2:0:3 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. Also listed under MG 845

IE 650 Queuing Systems I 2 1/2:0:3 Development of elements of queuing and loss theory. Single and multiple servers. 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: MA 616.

IE 651 Queuing Systems II* 2 1/1:0:3 Applications of queuing theory with emphasis on communications and vehicular traffic. Customer behavior, switching networks, over-flow traffic, alternate routing, feedback, priorities, control. Formulation of standards based on cost-benefit view-point. Prerequisite: IE 550 or MA 815.

IE 655 Microeconomic Models* 2 1/2:0:3 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 for the firm. Analysis of short-run costs. Capital investment and analysis under capital rationing: deterministic and stochastic models. Prerequisites: IE 627 or MG 860 or permission of instructor, and MA 616.

IE 671 Business and Economic Forecasting 2 1/2:0:3 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 658. Also listed under MG 671

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IE 675 Human Factors in Engineering Design* 2:13
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. (Not open to students who have taken IE 365.) Prerequisite: SS 189, or permission of instructor.

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, detection and control of hazards. (Not open to students who have taken IE 375.)

IE 776 Manufacturing Resource Planning* 2:1:0:3
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.) Prerequisites: IE 619 or instructor's permission, knowledge of computer programming.

IE 777 Manufacturing Improvement Curves* 2:1:0:3
Study of work design with emphasis on parameters affecting installation of overall system. Advanced work sampling, work-force balancing, ergonomic work loads, incentive for machine-controlled operations, computer-assisted planning of systems. Prerequisite: IE 606.

IE 778 Advanced Production Planning* 2:1:0:3
Prerequisites: IE 619 or equivalent.

IE 779 Advanced Work Systems Design* 2:1:0:3
Course will cover several perspectives on the manufacturing system. It will also describe the elements of the system and their interfaces. The conceptual structure will be reinforced by discussion of system planning and performance variation through simulation.

IE 780 Optimum Seeking Methods* 2:2:0:3
Algorithm construction and applications of computer-implemented search procedures. One-dimensional searches, including Fibonacci and golden section search; quadratic and cubic convergent methods. Successive approximations and variable metric (e.g., DFP) methods. Constraints, penalty functions, SUMT. Sensitivity, convergence and program efficiency. Prerequisites: IE 601 and either IE 627 or IE 631.

IE 781 Case Studies in Industrial Engineering and Operations Research Application of scientific and analytical methods to solving management decision-making problems, drawn from current practice and literature. Prerequisite: Instructor's permission.

IE 782 Technology Transfer to Developing Countries 2:1:0:3
Mechanisms of technology transfer. Ecological, social and economic factors in technology selection and utilization. Local efforts to adapt technology to local needs. National and international means to stimulate or block technology transfer. Technology and political influence. Case studies of technology transfer to newly industrializing countries.

IE 783 Time Series: Forecasting and Control* 2:1:0:3

IE 784 System Simulation 2:1:0:3
Prerequisites: EL 531 or MA 561 or equivalent.

IE 785 System Reliability 2:1:0:3
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 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 component reliability. Prerequisite: EL 631 or MA 561 or equivalent.

IE 786 Component Reliability* 2:1:0:3
Failure models for industrial components: exponential, Weibull, lognormal, gamma. Gumbel and other distributions. Fitting and hazard rates; graphical probability plots and maximum-likelihood parameter estimation and testing. Sampling plans based on life tests and accelerated life tests. Prerequisite: EL 531 or MA 561 or equivalent.

IE 787 Case Studies in Industrial Engineering and Operations Research Application of scientific and analytical methods to solving management decision-making problems, drawn from current practice and literature. Prerequisite: Instructor's permission.

IE 788 Industrial Safety Engineering* 2:1:0:3
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, detection and control of hazards. (Not open to students who have taken IE 375.)

IE 789 Computer Integrated Manufacturing Systems (CIMS) 2:1:0:3
CIMS encompasses all activities from planning and design of a product to its manufacture and shipping. This course will cover several perspectives on the manufacturing system. It will also describe the elements of the system and their interfaces. The conceptual structure will be reinforced by discussion of system planning and performance variation through simulation.

IE 790 Urban Systems Analysis* 2:1:0:3
The overall urban system. Modeling for prediction and management of major components: population, economy, land use, transportation network, facility location, government 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* 2:1:0:3

IE 886 Component Reliability* 2:1:0:3
Failure models for industrial components: exponential, Weibull, lognormal, gamma. Gumbel and other distributions. Fitting and hazard rates; graphical probability plots and maximum-likelihood parameter estimation and testing. Sampling plans based on life tests and accelerated life tests. Prerequisite: EL 531 or MA 561 or equivalent.
IE 852 Applied Regression and Analysis of Variance* 2 3/4:0:3
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 608.

IE 853 Design of Experiments* 2 3/4:0:3
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 608.

IE 870 Games and Decisions* 2 3/4:0:3

IE 911-912 Selected Topics in Operations Research and Industrial Engineering I, II* each 2 3/4:0:3
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 3/4:0:3
Examination of selected advanced topics at research frontiers of department's graduate program areas. Presentations by graduate students, faculty, visiting scientists. Prerequisites: 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 each 3 units
Original investigation in topic chosen by student. Conferences and progress reports required during work and final written report required; oral examination may be required 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 each 3 units
Post-master's investigating 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

William R. McShane, Professor of Transportation and System Engineering, Head, Department of Transportation and Industrial Engineering Director, Transportation Training and Research Center
B.E.E., Manhattan College, M.S., Ph.D., Polytechnic Institute of Brooklyn; Professional Engineer (N.Y., Cal. (Traffic))
Traffic engineering, highway capacity, expert systems in transportation, PC applications and models, economics and finances.

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; Professional Engineer (N.Y., N.J., Cal. (Traffic))
Transportation and industrial safety, environmental impacts of transportation, urban planning, pedestrian, bicycle planning, and human factors.

John Chu, Professor of Operations Research and Management Science
B.S., University of Cheklang (China); M.S., Ph.D., Iowa State University
Managerial decisions, behavioral approach, national and international affairs.

John C. Falcocchio, Professor of Transportation Engineering
B.S.C.E., M.S., Ph.D., Polytechnic Institute of Brooklyn; Professional Engineer (N.Y., Pa., Cal. (Traffic))
Transportation planning, public transportation, transportation of disadvantaged groups.

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, factory simulation

Walter Helly, Professor of 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 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 Operation 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 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, robotics

Philip A. Habib, Associate Professor of Transportation Engineering and Director of Manufacturing Engineering Program
B.E., CCNY, M.S., Ph.D., Polytechnic Institute Brooklyn, Professional Engineer (N.Y.)
Goods movement, highway engineering, transportation planning, terminal planning, ferry planning.

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

ADJUNCT FACULTY

Maureen Dolan, Adjunct Lecturer
B.A., Molloy College; M.S., Stevens Institute of Technology; M.S., Polytechnic Institute of New York

Chaim Steinberger, Adjunct Assistant Professor
M.S., Polytechnic Institute of New York
INFORMATION MANAGEMENT

Information management deals with information needed by people 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 executives with timely facts needed to make decisions.

Currently, there is a 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 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, and other project team members.

Polytechnic trains information management professionals who, after graduation, are usually assigned individual or team tasks, which they are able 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 objectives are to provide students with the educational background and skills to qualify for entry level positions as application programmers or analysts in the business world. Unlike computer science, where mathematics, science and software development are emphasized, information management is business oriented. Students must be aware 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 after entering industry without additional courses. Finally the program provides a solid foundation for the student who wishes to pursue graduate study.

Requirements for 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>Component</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computing: CS 112, CS 203, CS 204, CS 211, CS 308, MG 202</td>
<td>18</td>
</tr>
<tr>
<td>Management/System Analysis: IE 254, IE 300, IE 314, IE 320, IE 380, MG 300, MG 301, MG 304, MG 318, MG 390, MG 401</td>
<td>33</td>
</tr>
<tr>
<td>Humanities/Social Science: HU 101, HU 110, LA 100, LA 110, LA 120, LA 130, LA 131, LA 132, LA 140, LA 142, LA 143, LA 150, SS 104, SS 251, SS 252</td>
<td>45</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</td>
<td>21</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 for six credits of electives: MS 301, 303, 401 or 403.

Graduate courses may be taken as electives by qualified juniors and seniors with at least a B average who obtain advisors' approval. If the total number of credits exceeds those required for the bachelor's degree, these graduate courses may be credited toward a graduate degree in accordance with Polytechnic policy.

Four-Year Programs

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.

Cooperative Program & Internships

A five-year cooperative education program is available which permits students to integrate academic courses and career preparation. While earning the B.S. degree, students are able to earn up to 75% of their college expenses. Students who wish a less intensive work experience as part of their educational may wish to enroll in a summer internship with advisers' permission.

Transfer Students

Transfer students from other accredited schools are accepted into the B.S. program after evaluations of their transcripts by faculty advisers. Graduates of technology programs may fulfill bachelor's degree requirements in two to three-and-one-half years, depending upon the scope and level of their previous education.
### Typical Courses of Studies for the Bachelor of Science Degrees in Information Management

#### 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.</strong></td>
<td><strong>Lab</strong></td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing and the Humanities</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LA 110</td>
<td>Technol. &amp; Soc. in Hist.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
<td>Perspective</td>
<td>4</td>
</tr>
<tr>
<td>MG 202</td>
<td>Computers in Mgt</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>SS 104</td>
<td>Cont. World History</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PE 101</td>
<td>Phys. Ed. I</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

#### Sophomore Year

<table>
<thead>
<tr>
<th><strong>Second Semester</strong></th>
<th>Hours/Week</th>
<th><strong>No.</strong></th>
<th><strong>Subject</strong></th>
<th><strong>Cl.</strong></th>
<th><strong>Lab</strong></th>
<th><strong>Cr.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>HU 200</td>
<td>Writing and the Humanities II</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>CS 112</td>
<td>Programming in Pascal</td>
</tr>
<tr>
<td>MA 102</td>
<td>Calculus II</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>MA 102</td>
<td>Calculus II</td>
</tr>
<tr>
<td>MG 304</td>
<td>Accounting Fund</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE 102</td>
<td>Phys. Ed. II</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
<td><strong>15</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Junior Year

<table>
<thead>
<tr>
<th><strong>Junior Year</strong></th>
<th>Hours/Week</th>
<th><strong>Second Semester</strong></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
<td><strong>Cl.</strong></td>
<td><strong>Lab</strong></td>
</tr>
<tr>
<td>CS 203</td>
<td>Comp. Prog. II</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>IE 254</td>
<td>Intro. to Ind. Eng</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LA 131</td>
<td>The Biological World</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>LA 132</td>
<td>The Behavioral World</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>SS 251</td>
<td>Microeconomics</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PE 103</td>
<td>Phys. Ed. III</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>17</strong></td>
<td><strong>18</strong></td>
<td></td>
</tr>
</tbody>
</table>

#### Senior Year

<table>
<thead>
<tr>
<th><strong>Senior Year</strong></th>
<th>Hours/Week</th>
<th><strong>Third Semester</strong></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
<td><strong>Subject</strong></td>
<td><strong>Cl.</strong></td>
<td><strong>Lab</strong></td>
</tr>
<tr>
<td>IE 380</td>
<td>System Simulation</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LA 150</td>
<td>Making of Connect.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MG 301</td>
<td>Organizational Behav. Electives</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>15</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Total credits required for graduation: 128**

#### FACULTY

The program is administered by the Division of Management. The faculties of industrial engineering, operations research and management, which play major roles in Information Management, are listed below.

- **Melvin L. Meer**, Assistant Professor of Management
- **John T. Chu**, Professor of Operations Research and Management Science
- **Norbert Hauser**, Professor Industrial Engineering and Management Science
- **Walter Helly**, Professor of Operations Research
- **John H.K. Kao**, Professor of Industrial Engineering and Operations Management
- **A. George Schillinger**, Professor of Management, Chairman, Management Division
- **Joachim I. Weindling**, Professor of Operations Research and Systems Engineering
- **Anthony J. Wiener**, Professor of Management
- **Herman Grau**, Associate Professor of Industrial Engineering
- **Seymour Kaplan**, Associate Professor of Operations Research and Management Science
- **Harold G. Kaufman**, Associate Professor of Management
- **Ravinder Nanda**, Associate Professor of Industrial Engineering and Operations Management, Co-Director of Operations Management Program
- **Byron L. David**, Instructor of Management
- **Vincent K. Omachonu**, Instructor of Industrial Engineering and Operations Management
- **Madhuri Kadiyala**, Academic Associate, Management
INTER-INSTITUTIONAL AND COOPERATIVE PROGRAMS

Polytechnic University has made cooperative arrangements with other institutions to expand offerings available to students. Some of these programs are described in this section. All students who wish to participate in cooperative programs 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 are designed to provide ideal solutions for these overlapping areas.

Cooperating Science and Engineering Programs at Polytechnic

The M.P.A. degree is awarded by New York University upon successful completion of the program. The M.S. degree is awarded simultaneously by Polytechnic University in any of the following programs:

- Aeronautics and Astronautics
- Applied Mechanics
- Bioengineering
- Chemical Engineering
- Chemistry
- Civil Engineering
- Electrical Engineering
- Industrial Engineering
- Mathematics
- Mechanical Engineering
- Metallurgical Engineering
- Operations Research
- Physics
- Systems Engineering
- Transportation Planning

Program Eligibility and Duration

The Program is open to qualified students with acceptable undergraduate backgrounds in mathematics, science or engineering; some departments accept students from quantitatively-oriented social science programs. Students must be admitted through one of the cooperating departments at Polytechnic University 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. The joint program provides for significant time saving compared with sequential study for two master's degrees.

It is assumed that students have undergraduate science or engineering backgrounds which are essentially equivalent to Polytechnic degrees. Students with deficiencies in undergraduate preparation may be required to take additional credits for completion of degrees. Students are expected to be familiar with elementary digital computational procedures and with a programming language such as FORTRAN or PL/1. Students without these backgrounds 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. Brochures summarizing them are 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 the following courses:
   - P11.1013 American Public Administration and its Political Environment
   - P11.1016 Organization Theories in a Public Context
   - P11.1018 Microeconomics for Public Management, Planning and Policy Analysis

4. Elective Courses in Public Administration
   (12 credits). Three courses, usually in accordance with the suggestions shown by the Polytechnic program.
5. 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 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, who jointly supervise the project. 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 advisers. Prerequisite: completion of at least 27 credits in the joint program.

6. Seminar
(no credit). Joint seminars including guest speakers covering technical and scientific problems related to public policies. Participation will be required of all students in the program.

Project Topics — Actual topics will be determined by students and their advisers.

Admission — Applications for admission to the combined program are available from program coordinators. Applicants should complete the application forms for Polytechnic — clearly indicating the desired Polytechnic program — and that for NYU/GPA, and send them to the program coordinators enclosing separate checks for the two application fees, only one set of transcripts and references is required. Admission to both schools is then coordinated through the Polytechnic office.

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 application forms.

Registration — Students 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, students will be assigned to Polytechnic advisers with whom overall program should be planned. In addition, students will be assigned an adviser from NYU/GPA by the liaison office of that school.

Further Information — Additional information may be found in the NYU/GPA catalog. Brochures and application forms are available from the program director:
Professor Joachim I. Weindling
POLY/NYU Program Director
Polytechnic University
333 Jay Street
Brooklyn, NY 11201

INTER-INSTITUTIONAL AND COOPERATIVE PROGRAMS

COOPERATIVE (3-2) ENGINEERING PLAN

The roles of engineers and scientists in our society have changed significantly during recent years. Engineers and scientists have been called upon increasingly to assume managerial and administrative responsibilities in both the private and public sectors. As a result, there are growing student demands for programs which make it possible to include more courses in the humanities and social studies than can be accommodated in standard engineering curricula.

The Cooperative (3-2) Engineering Plan has been developed so that the needs of these students are satisfied. Under the plan, students register at cooperating liberal arts colleges for three years of study, and then transfer to Polytechnic University as engineering majors for two additional years (nominally). At the end of five years, students have (Normally) completed the requirements for bachelor's degrees at both the liberal arts college and Polytechnic, whereas usually at least six years of study would be required for those not availing themselves of this plan.

Those wishing to pursue studies under the combined plan should make inquiries at the cooperating liberal arts college of their choice and enroll in the plan at that school.

Upon satisfactory completion of the three-year segment of the combined program in the liberal arts college and with the official recommendation of that school, the student would be admitted to an engineering program at Polytechnic University to complete requirements for the bachelor's degrees from each institution. The Polytechnic University is cooperating officially in the combined plan with the liberal arts colleges of the following institutions:

Adelphi University, Garden City, N.Y.
C.W. Post Campus, Long Island University, Brookville, N.Y.
St. John's University, Jamaica, N.Y.
State University College, Oneonta, N.Y.

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, students enroll at one of the cooperating schools 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 University 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. Polytechnic University has formal agreements for cooperation in this plan with the following institutions:

Brooklyn College (City University of New York), Brooklyn, N.Y.

*Note: Any changes in the requirements by New York University for the M.P.A. degree may have the effect of increasing the number of credits required for groups (3) and (4) above, and therefore, the number of credits required for the joint M.S./M.P.A. program. Contact the program director for the latest information.
INTER-INSTITUTIONAL AND COOPERATIVE PROGRAMS

(See "Transfer from Brooklyn College")
Lehman College (City University of New York), Bronx, N.Y.
Westchester Community College, Valhalla, N.Y.

TRANSFER FROM BROOKLYN COLLEGE

Polytechnic University 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. Upon completion of the Brooklyn College component of the coordinated program, students transfer to Polytechnic for two-and-one-half years additional study to fulfill requirements for the degree of bachelor of science in any of the following fields: aerospace, chemical, civil, electrical, industrial, mechanical, or metallurgical engineering.

Students who complete the Brooklyn College pre-engineering component with overall science and mathematics course grades 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, 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. Mendelssohn, Dept. of Physics
Brooklyn College (CUNY)
Bedford Avenue & Avenue H
Brooklyn, New York 11210
Phone: (718) 790-5418

POLYTECHNIC/MARIST JOINT ENGINEERING PROGRAM

Polytechnic University and Marist College conduct a joint program on the Marist campus in Poughkeepsie, New York, for the purpose of providing undergraduate education in electrical and computer engineering for residents of the mid-Hudson valley. The course offerings are selected from the Polytechnic electrical and computer engineering curricula (as described elsewhere in this catalog). Marist College provides the instruction for the non-engineering courses (mathematics, physics, chemistry, humanities, social sciences); Polytechnic faculty teach all of the engineering courses.

For further information call or write:
Professor Sidney Shamis
Engineering Program
Marist College
Poughkeepsie, New York 12601
Phone: (914) 471-3240 ext. 569

CROSS REGISTRATION WITH LONG ISLAND COLLEGES

Through a consortium of Long Island Colleges, LIRACHE (Long Island Regional Advisory Council on Higher Education), 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 students’ home institutions.

The following conditions prevail; exceptions are made only under unusual or extenuating circumstances:

• Permission is granted only when the home institution does not offer such courses at any time.
• Students must receive approval from both home and host institutions for all cross-registered courses prior to admission.
• No cross registration fees are charged. Students are obligated to pay their home institution the regular tuition which would have been charged if the courses were taken at the students’ own schools; however, students are responsible for any special fees charged by host institutions. Such fees are paid directly by the students to the institutions at which they cross register.
• Grades for all courses are sent directly to the Registrar of the students’ home institutions and are processed in the manner of those schools.
• Students participating in this academic enrichment program are subject to the academic regulations, including grading systems, calendar deadlines, and academic honor systems of the host institutions.

Participating institutions are:
In 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

In SUFFOLK County:
Polytechnic University (Long Island Campus)
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 Polytechnic Long Island Campus.
MANAGEMENT

Among the programs offered by the Division of Management are an undergraduate bachelor of science degree in information management*, and four graduate degrees: master of science in management**, master of science in organizational behavior, master of science in telecommunications management***, and master of science in operations management****. The graduate degrees are primarily evening programs offered to both full-time and part-time students. These graduate programs are open to any students who have earned bachelors' degrees with B averages from accredited schools and have satisfactory scores on the Graduate Management Admission Test (GMAT). Students who show potential for advanced studies but have undergraduate averages below B, or have not yet taken the GMAT, may be admitted as Special Students at registration for any semester; satisfactory performance at Polytechnic will permit later application for degree status.

In addition to the programs listed below, students may be interested in University offerings in Industrial Engineering and Operations Research. These programs are listed elsewhere in this catalog.

MASTER OF SCIENCE PROGRAMS IN MANAGEMENT

The Program — This program is aimed at developing competence in planning and decision-making and in the selection, allocation and direction of human, financial, physical, technological and organizational resources. In contrast to many M.B.A. programs the M.S.M. program emphasizes management rather than staff skills in a choice of 9 concentrations:

- Construction Management
- Economics and Finance
- Human Resources Management
- Information Management
- Management and Administration
- Management Science
- Public Policy
- Technology Management
- Transportation Management

These management skills can be applied to a broad range of professional settings in the private as well as the public sectors; 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 pragmatic approaches to management and is intended to train professional managers who can function effectively in complex managerial systems, especially those in which technology plays significant roles.

Admission — In addition to holding accredited bachelors degrees, all students must take the Graduate Management Admission Test (GMAT) or an acceptable equivalent test. Students who have not taken the test can be admitted as provisional students and are required to take it before completion of their second semester in order to be admitted as degree candidates.

Degree Requirements — The M.S.M. requires completion of 12 courses, or 36 units, as described below, with a minimum of a B average. Students who are less well-prepared may be required to take up to 4 additional courses, or 12 units, as described in the next paragraph. Transfer credits may be granted of 9 units for graduate courses in management taken previously, as evaluated by advisers.

The Curriculum

1. Basic and Core Courses. A management base and core curriculum form nine required courses upon which students can build a variety of specializations within the degree programs. Basic and core courses provide intensive introductions to the several disciplines basic to professional management. Students who have taken these courses elsewhere or previously at Polytechnic, or who have had equivalent experiences may be excused from them. Upon proof of competence, advisers can waive any corresponding basic or core courses. Students must then substitute electives or basic courses, as required by advisers, to complete the minimum of 36 units (12 courses) for the master's degree. If one or more basic courses are required, these must be taken in addition to the 12 courses required for the degree, except if one or more core courses are waived.

The Basic Courses:

- MG 502 Computers in Management
- MG 503 Economic Environment of Management
- MG 504 Managerial Accounting
- MG 505 Statistical Analysis

The Core Courses:

- MG 600 Management Process
- MG 601 Organizational Behavior
- MG 606 Managerial Finance
- MG 607 Marketing Management
- MG 608 Managerial Economics

2. Areas of Concentration. Students must choose areas of concentration. These may be one of those listed below or, with the adviser's approval, a set of courses designed to meet students' special needs. A minimum
of four must be selected in any one area of concentration. Courses in all the available options are shown below.

3. Free Electives. Two graduate courses may be chosen from those offered by any programs of Polytechnic with the adviser's consent.

4. Business Policy and Strategy, with Project (MG 970). This required integrating course is recommended for students' final semester. It includes a project normally in the area of students' specialization. In special cases, MG 997. Thesis for Degree of Master of Science, may be substituted for students who wish to produce a major dissertation in a specialty.

Concentration Course Requirements

Each concentration sequence consists of four courses. Students who take more than the minimum number of required courses may count additional courses as electives. Substitutions may be made with advisers' approval in any concentration areas.

Information Management
Select four:
MG 626 Human Resources Information Systems
MG 654 Economics of Information Systems
MG 716 Commercial Data Processing Systems and Design
MG 736 Management Information Systems
MG 820 Project Management
CS 603 Information Structures and Algorithms
CS 681 Information Privacy and Security

Construction Management
Select four:
MG 631 Organizational Theories
MG 610 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 766 Financial Institutions

Electives — Select three:
MG 615 Labor Economics
MG 640 Resource Economics
MG 671 Business and Economic Forecasting
MG 850 Financial Planning, Internal Reporting and Operational Control
MG 912 Seminar in Investment Analysis
MG 963 Seminar in Financial Planning and Control

Human Resources Management
Required:
MG 612 Human Resources Management
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 624 Organization Development
MG 625 Seminar in Career Management
MG 626 Human Resource Information Systems
MG 627 Human Resources and Technological Change
MG 631 Organizational Theories

Management and Administration
Required:
MG 630 Operations Management

Select three:
MG 612 Human Resources Management
MG 624 Organization Development
MG 633 Research Methods
MG 664 Management and the Legal System
MG 700 New Enterprise and Small Business Management
MG 705 Managerial Planning Process
MG 886 Strategic Management of Productivity

Management Science

Students electing this option should substitute MA 551 for MG 555 in the basic courses.

Note that IE 624 has several prerequisites.

Select four:
MG 810 Project Planning and Control
MG 714/IE 614 Modeling of Social Systems
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

Public Policy
Select four:
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
MG 866 Technology Management and Policy
ES 927 Energy Policy Issues
MG 714/IE 614 Modeling of Social Systems

Technology Management
Required:
MG 866 Technology Management and Policy

Select three:
MG 624 Organization Development
MG 627 Human Resources and Technological Change
MG 630 Operations Management
MG 645 Productivity Management
MG 672 Technological Forecasting
MG 820 Project Management
MG 865 Research Development and Management of Innovation
MG 887 Corporate Strategy for Technology-Intensive Industries
MG 888 Strategic Management of Productivity
MG 714/IE 614 Modeling of Social Systems

Transportation Management
Select four:
MG 853/TR 751 Transportation Finance
MASTER OF SCIENCE PROGRAMS IN ORGANIZATIONAL BEHAVIOR

Program — A graduate evening program is offered to students who wish to specialize in 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 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 their applications.

The Curriculum

1. Required Core courses. An organizational behavior base consists of four core courses upon which the student can build a variety of specializations within the degree program. Core courses provide intensive introduction to several areas 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 waivers from advisers.

Students who have not completed an undergraduate course in statistics will be required to enroll in MG 505, Statistical Analysis.

The core courses are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MG 600 Management Process</td>
<td>3</td>
</tr>
<tr>
<td>MG 601 Organizational Behavior</td>
<td>3</td>
</tr>
<tr>
<td>MG 631 Organization Theory</td>
<td>3</td>
</tr>
<tr>
<td>MG 633 Research Methods</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total units required:</strong></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

2. Areas of Concentration. Students must choose two areas of concentration, each consisting of two courses. These may be two of those listed below or, with adviser’s approval, may consist of a series of four courses designed to meet students’ special needs.

Courses in each of the following areas of concentration are shown below:

**Career Management**
- MG 611 Career Management
- MG 625 Seminar in Career Management

**Industrial Relations**
- MG 613 Industrial Relations

**Personnel and Human Resources**
- MG 612 Human Resources Management
- MG 622 Personnel Psychology

**Training and Development**
- MG 623 Training in Organizations
- MG 624 Organization Development

3. Free Electives. Three appropriate graduate courses may be chosen from any programs at Polytechnic. These could include courses from any concentrations not required in students’ programs, other courses in management, or courses in computers, psychology and social sciences.

4. Research Projects
- MG 634 Applied Research Methods

All students are required to submit a research project as part of the course.

CERTIFICATE PROGRAMS

The Division of Management offers several certificate programs designed for professionals with work experience. A certificate program requires five courses, which are selected according to individual needs. Applicants for certificate programs must hold bachelor’s degrees. On completion of a sequence with a B or better, students are issued certificates. Those who choose to work toward master’s degrees are able to apply all courses taken toward a certificate, upon admission, toward fulfillment of degree programs. Additional information may be obtained from the Division.

Management Certificate — This program is designed to foster professional and personal growth through intensive studies of the latest advances in management processes 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
- Finance
- Human Resources
- Management & Administration
- Operations Management
- Public Policy
- Technology Management

Organizational Behavior Certificate — This program involves intensive studies of the latest knowledge and techniques for dealing with human problems in organizations. Individualized programs make it highly appropriate for specialists as well as generalists to improve and update their knowledge and skills in areas ranging from individual motivation to organizational development.
MANAGEMENT

UNDERGRADUATE COURSES

MG 202 Computers in Management 2:3:3
Introduction of basic computer hardware and software concepts. Survey of operating systems and programming languages. Heavy emphasis on personal computer applications and management-oriented application packages in word processing, database management, spreadsheets, communications, and business graphics. Students have access to Texas Instrument's professional computers.

MG 300 Management Process 3:0:3
Introductory management course for undergraduates. Focus is on the management process: planning, organizing, staffing, controlling, directing and decision making. Attention is given to the roles of various disciplines within management as well as to the traditional business functions of marketing, accounting, finance, production, engineering, 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. Prerequisites: SS 189. Also listed under SS 199.

MG 304 Accounting Fundamentals 3:0:3

MG 316 Commercial Data Processing Systems Design 3:0:3
Functional relationships of information across the commercial environment and their relevance in the design of Management Information Systems. Also covered are the present and future roles of personal computers and terminals in information interchange. The necessary communication techniques and protocols to accomplish mainframes to personal computer connections are included. Prerequisite: MG 202.

MG 390 Management Decision Making 2:3:3
Students integrate specialized areas of economics and management previously studied by analyzing and making decisions in environments based upon a computer-processed management simulation. Students are organized into competing companies making quarterly decisions on production, price, research, marketing, etc. Periodic oral and written reports; final oral and written reports presented to Board of Directors. Note: Normally, this is a three-credit course. However a two-credit version, omitting written reports, may be offered to non-IM Students. Prerequisites: SS 251, IE 300, MG 304, or permission of Instructor.

MG 401 Senior Project 3 credits
Independent work integrating students' knowledge under faculty guidance. Students design systems required to manage information regarding specific management functions. Prerequisites: senior standing in information management.

GRADUATE COURSES

MG 502† 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 language important to managers. Examples and cases of decision-support systems and their application in office automation, financial analysis and other business applications.

MG 503† Economic Environment of Management 2:5:0:3
Central problems of economic society, supply and demand analyses, structures of industrial markets, factors of production, profits and incentives, national income accounting, income determination, business cycles, monetary and banking systems, governmental influences on the economy, international trade and finance.

MG 504† Managerial Accounting 2:5:0:3
Aspects of accounting of practical use to the manager. Stress on understanding of financial statements rather than on bookkeeping procedures. Internal management usage of accounting data; job orders, process and standard costing; relations among accounting, economic and financial perspectives.

MG 505† Statistical Analysis 2:5:0:3
Fundamental statistical models and their uses 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 600† Management Process 2:5:0:3
Establishment of conceptual perspectives of major schools of management thought, including scientific management, classical administrative theory, human relations, behavioral systems theories.

MG 601† Organizational Behavior 2:5:0:3
Integration of behavioral science theories, 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; communication, organization structures and processes, impacts of technology, career development.

MG 602† Managerial Finance 2:5:0:3
Analysis of principles and practices of finance function and its application in organizations. Survey of uses of financial instruments, sources and uses of short- and long-term funds available to business; capital budgeting under certainty and uncertainty; cost of capital and dividend policy; working capital management. Prerequisite: MG 503 or equivalent.

MG 607† Marketing Management 2:5:0:3
Foundation course in marketing processes and institutions. Consumer motivation and behavior, pricing determination and policies, product planning and development, promotion management, channels and means of distribution, influences of government. Cases and managerial aspects stressed. Co/Prerequisite: MG 503.

MG 608 Managerial Economics 2:5:0:3
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 503.

MG 609 Managerial Accounting and Finance 2:5:0:3
MG 611 Career Management 2/4:0:3
An examination of careers from the perspectives of both management and individuals. Specific issues include career stage models, organizational entry, career pathing, mid-career crisis, career change, continuing education and retraining, 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 2/4:0:3
Personnel functions are investigated from the perspectives of individual managers 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 2/4:0:3
Policies and philosophies of management, organized labor problems. Evaluation of industrial relations problems, particularly those of collective bargaining, emphasizing interrelationship with social, economic and legal trends. Co/Prerequisite: MG 600 or permission of instructor.

MG 614 Collective Bargaining 2/4:0:3
Analyses of the 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 622 Personnel Psychology 2/4:0:3
Examination of theory, research and practice concerning individual differences relating to organizational behavior with emphasis on the personality selection process, measurement of predictors, criteria for validation and decision-making strategies. Prerequisites: MG 601 and MG 505 or permission of instructor.

MG 623 Training in Organizations 2/4:0:3
The roles of training in organizations, focusing on department and line managers. Subjects addressed include need analysis, preparation of employees for jobs, management development, training program design, evaluation and employee obsolescence. Prerequisite: MG 601 or permission of instructor.

MG 624 Organization Development 2/4:0:3
Applied theory and research related to process of managing change in organizations. Practical application of group, intergroup, and individual changes. Planned structural revisions in formal organizations. Dynamics of organizational change processes. Experimental techniques and seminar approaches emphasized. Prerequisite: MG 601.

MG 625 Seminar in Career Management 2/4:0:3
Examination of the latest concepts, research and practices pertaining to professional and managerial careers in organizations. Emphasis is on current issues and problems in career management. Experts and resource materials utilized in examining research findings as well as in studying career development and planning practices and programs which have been established in organizations. Prerequisite: MG 601 or permission of instructor.

MG 626 Human Resource Information Systems 2/4:0:3
Design, selection, implementation, enhancement and operation of Human Resource Information Systems (HRIS) in organizations. Organizational, legal and political issues as well as hardware, software, applications and communications in HRIS. The uses of time-sharing, personal and minicomputers and mainframes. Focus on design and use of HRIS to facilitate objectives of human resource functions, as well as to support entire organizations. Also listed under SS 876.

MG 627 Human Resources and Technological Change 2/4:0:3
Examination of the impact of technological changes on human resources and their management. An overview of technological changes and their effects on the work force, focusing on changes in supply and demand as well as the obsolescence of knowledge and skills. Topics include utilization, human resource planning, job redesign, resistance to change, organizational change, continuing education and retraining, productivity and innovation, inter-organizational cooperation, roles of government, and international issues. Corequisite: MG 601 or permission of the instructor. Also listed under SS 879.

MG 630 Operations Management 2/4:0:3
Analytic techniques for designing and operating production and service systems, including facility layouts and locations, assembly line balancing, job sequencing, inventory control, and project planning. Introductory linear programming and other formal methods. Cases and managerial perspective.

MG 631 Organization Theory 2/4:0:3
Analyses of theories of large-scale organizations focusing on characteristics of bureaucracy, suborganization, human dynamics and informal systems, influence and control systems, planned change. Examination of both formal and informal organizations through varieties of research studies. Prerequisite: MG 601 or permission of instructor.

MG 632 Research Methods 2/4:0:3
An introduction to theories and techniques of research methods. Primary objectives are to provide understanding and appreciation of why and how organizational research is carried out. Survey of research methods. Research projects are designed and analyzed. Prerequisite: MG 605 or permission of instructor.

MG 633 Applied Research Methods 2/4:0:3
Integration and application of advanced research techniques utilized in studies of organizations. Students develop and carry out individual applied research projects. Prerequisite: MG 633 or permission of instructor.

MG 640 Resource Economics 2/4:0:3
Theories of exhaustible natural resources with special emphasis on fossil fuels. Theories of extraction logistics and resource exhaustion. Theories of pricing and allocation of exhaustible resources under economic conditions of competition, monopoly and oligopoly. Present-day behavior of world oil markets and domestic and international markets for natural gas and coal are discussed, as well as policy problems. Prerequisites: SS 261 and MA 103, or IE 665, or permission of instructor.

MG 645 Productivity Management 2/4:0:3
Modern approaches to productivity measurement, evaluation, planning and improvement in manufacturing and service industries. Participants develop productivity models for various types of organizations. Prerequisite: Graduate standing or permission of instructor. Also listed under IE 645.

MG 650 Management of the Information Function 2/4:0:3
Structures of information processing, storage, transport and user services within organizations. Relations of distributed processing, distributed databases, and telecommunication network topology to organizational structures, Management of value and data integration, Hardware and software evaluation and acquisition, benchmarking, information systems contracting, pricing of information services, Operation of information systems.

MG 652 Telecommunications Policy, Regulation, and Law 2/4:0:3
Relationships between the development of the telecommunications industry and commerce and society generally. Options and opportunities offered by recent regulatory and policy issues.
MANAGEMENT

MG 654  Economics of Information Systems  2½:0:3
Concepts of market supply and demand as they apply to markets for information services and products; rationales for, and nature of, emerging applications of information systems; availabilities and pricing of services; methods of economic decision making and justification of business information systems.

MG 664  Management and the Legal System  2½:0:3
Impacts of the legal system on corporate strategy, managerial decision and planning processes. Issues covered include: protection of intellectual and technological properties; consumer, contract, commercial and secured financing laws; employer liability to, and for, employees; negligence and risk-management from legal and corporate viewpoints, and constitutional and regulatory aspects of conducting business on a multi-state basis. The legal system from the perspective of individual managers as agents, contract-makers, etc.

MG 671  Business and Economic Forecasting  2½:0:3
Forecasting for managerial decision and 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  2½:0:3
Introduction to problems of technological forecasting. Morphological analyses, extrapolation of trends, heuristic and intuitive forecasts. Consideration of rational directing of technological changes. Students prepare forecasts on topics of choice. Also listed under SS 672

MG 700  New Enterprise and Small Business Management  2½:0:3
Characteristics, opportunities, and hazards of new and small business firms with special attention given to technology, engineering and manufacturing concerns. A variety of operating problems in different stages of a small company's life cycle are considered. Actual business cases involving opportunity-finding and decision-making are utilized for students to gain insights into their attitudes towards risk-taking and in developing their own action-taking skills. Prerequisite: Advanced Standing

MG 705  Managerial Planning Processes  2½:0:3
Introduction to strategic management and to formal planning as methods for translating business goals into procedures or actions. Tactical planning at operating levels. Development of foresight and classical methods for gathering information essential to decision-making in large-scale organizations. Prerequisites: MG 600 and MG 601.

MG 714  Modeling of Social and Managerial Systems  2½:0:3
This course introduces the student to general systems theory as it applies to managerial and social phenomena. Systems are 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, and areas related to their individual interests. Also listed under IE 514

MG 716  Commercial Data-Processing Systems Design  2½:0:3
Functional relationships of information across the commercial environment and their relevance in the design of management information systems. Present and future roles of personal computers and terminals in information interchange. Necessary communication techniques and protocols to accomplish mainframes to personal computer connections. (Not open to students who have taken MG 316.) Prerequisite: MG 502.

MG 727  Case Studies in Management Science*  2½:0:3
Applications of scientific and analytic methods for solving decision-making problems, drawn from current practice and literature. Prerequisite: permission of the instructor. Prerequisite: MG 630.

MG 736  Analyses and Design of Management-Information Systems  2½:0:3
Roles of information systems in management decision-making processes. 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 502.

MG 785  Financial Institutions  2½:0:3
Financial institutions and their importance in the economy. Capital and money markets, commercial banking systems, federal banking systems, investment banks, insurance companies, savings and loan associations, mutual funds, brokerage companies, international banking.

MG 800  Policy Analysis and Planning  2½:0:3

MG 810  Project Planning and Control  2½:0:3
Network planning techniques for project management and resource allocation. Emphasis on PERT, LON, CPM and probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Network development, computer adaptation, progress reports and project monitoring. Prerequisite: knowledge of computer programming. Also listed under IE 620.

MG 820  Project Management  2½:0:3
Specific managerial concepts and techniques related to management of projects in research and development, construction, engineering, and data processing. Functional and administrative structures, coordination of activities, manpower planning, feasibility analyses, negotiations and contracts.

MG 825  Construction Administration  2½:0:3
Management techniques of construction are discussed in relation to alternate means of project execution. Organizational structure, management systems, and controls are examined from the point of view of owners, the constructors, and the professional construction managers.

MG 826  Construction Estimates and Costs  2½:0:3
Techniques for estimating costs of capital projects and methods for effective cost control during project execution are taught with emphasis on principles of good management. Class project.

MG 827  Specifications and Contracts  2½:0:3
Principles of contract law applied to construction, legal problems in preparing and administering construction contracts. Prerequisite: MG 825. Also listed under CE 827

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 504.

MG 864  Product Planning  2½:0:3
Systematic studies of processes followed by successful companies in creating commercially viable products from technology developed by or available to them. Steps involved up to market entry are reviewed: feasibility analysis, initial market prediction, evaluation, marketing research, manufacturing preparation, market testing, etc. Financial aspects of developing products. Prerequisites: MG 600 and MG 607.
MG 865 Research, Development and Management of Innovation 2 1/2:0:3
Introduction to the environment of technological growth with reference to the economy, to companies and to management of the R and D function. Examination of policies and factors which affect innovation in industry. Methods for assessing and forecasting technology, delays, cross-impacting scenarios, parameter extrapolation, enveloping, etc. Problems in managing research and development by private enterprise during rapid technological changes. Prerequisite: MG 600.

MG 866 Technology Management and Policy 2 1/2:0:3
Topics and issues in private and public management; considerations of technology in strategic planning for high-technology corporations; government's role in directing technology, defense space, the SST and energy. Managing large-scale technological enterprises. Science and technology in international relations.

MG 867 Corporate Strategy for Technology-Intensive Industries 2 1/2:0:3
Corporate Strategy for Technology-intensive Industries is designed as a general management course. It focuses on the emerging technology-strategy relationship in the large technology-based corporation. This relationship is treated from three different perspectives: the corporate strategy of the individual firm, the competitive structure of an entire industry, and the "industrial policy" of a national government. This course will also be comparative in nature. The strategic management of technology in several different countries and industries will be studied and compared. The course will employ conceptual and empirical readings and relevant case studies.

MG 868 Strategic Management of Productivity 2 1/2:0:3
Issues relating to U.S. productivity relative to that of its trading partners and competitors in international trade. Analyses of American management strategies. Current controversies and their theoretical and empirical foundations. Time horizons for research and development, for market forecasting and new product development, for financial controls and portfolio analysis of growth. Long-term strategic roles for productivity in manufacturing and in providing services within the firm or to the market. Reassessment of the strategic function of the management of production. Cases and Readings.

MG 912 Seminar in Investment Analysis* 2 1/2:0:3
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, as business cycles, currency markets, and profit repatriation restrictions, for individual and corporate investment decisions.

MG 963 Seminar in Financial Planning and Control 2 1/2:0:3
Capital budgeting and investment valuation under certainty and uncertainty. Application of portfolio theories and mathematical programming to corporate investment alternatives. Management of alternative source 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 503 and MG 608, or permission of instructor.

MG 970 Business Policy and Strategy 2 1/2:0:3
Integration of functional disciplines studied in the master's program to understanding 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 corporate opportunities. Cases, research paper. Prerequisite: advanced standing.

FACULTY

Aaron Feinsot, Dean of Management
A.B., Union College; M.A., Ph.D., New York University

John T. Chu, Professor of Operations Research and Management Science
B.S., University of Chekiang (China); M.S., Ph.D., Iowa State University
Managerial decision making, organizational behavior, design of complex systems.

A. George Schilling, Professor of Management
B.E.E., CCNY; M.S., Eng. Sc.D., Columbia University
General management, technology management, corporate strategy

Anthony J. Wiener, Professor of Management
A.B., J.D., Harvard University
Corporate strategy, forecasting and planning, technology management, public policy

Nancy Needham, Industry Professor of 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

Harold G. Kaufman, Associate Professor of Management
B.M.E., Cooper Union; M.I.E., Ph.D., New York University
Career management, science and engineering manpower obsolescence and continuing education

Melvyn L. Meer, Assistant Professor
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M.S. (Chem. Eng.) Polytechnic University of Denmark
MANAGEMENT

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Stanley J. Jacoby, Adjunct Associate Professor
B.S., Polytechnic Institute of New York; M.S., Columbia University; M.M.S., Stevens Institute of Technology; Professional Engineer

Patrick McNells, Adjunct Associate Professor
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Ary Moasimen, Adjunct Associate Professor
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Thomas Noone, Adjunct Associate Professor
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Kenneth Walden, Adjunct Associate Professor of Management
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Thomas A. Dougherty, Adjunct Assistant Professor
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Robert A. Fitzgerald, Adjunct Assistant Professor
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Mark Kurman, Adjunct Assistant Professor
B.A., New York University; M.A., Bowling Green State University

Robert Schiffer, Adjunct Assistant Professor
B.S., M.B.A., Adelphi University

Janis Jiruska, Adjunct Instructor
B.A., New York University

Kenneth M. Rubin, Adjunct Instructor
B.B.A., Baruch College; M.B.A., St. John’s University

Joel H. Joseph, Lecturer
B.A., Yale University; J.D., Hofstra University
MANUFACTURING ENGINEERING

Polytechnic has an active interest in manufacturing engineering, and diverse curricula leading to degrees or concentrations related to manufacturing. These include:

- Graduate and undergraduate degrees in Industrial Engineering, the historical focus of manufacturing engineering. Within these degrees, students may take a range of courses including manufacturing processes, manufacturing resource planning, and robotics applications;

- Course sequences related to manufacturing within most of the engineering programs, including: Metallurgy & Materials Science, Electrical Engineering, Industrial Engineering, Mechanical Engineering;

- Degree programs leading to the M.S. degree in Manufacturing Engineering of Electronic Materials, jointly administered by the Metallurgy and Materials Science Program and Industrial Engineering Program;

- Opportunities to pursue Ph.D. dissertations on topics related to manufacturing engineering in any of the programs named herein.

This section of the catalog describes only the M.S. (Manufacturing Engineering of Electronic Materials) in detail. All other concentrations and courses sequences are shown under the catalog sections for the respective programs. The range of available courses is also indicated in this section, with course descriptions found in the individual catalog sections.

MANUFACTURING ENGINEERING: AN OVERVIEW

Manufacturing engineering holds great opportunities because its challenges are so vast. New technology in materials, optics, imaging, robotics, flexible automation, computer aided engineering (CAE), and computer integrated manufacturing systems (CIMS) provide new means of accomplishing tasks. New techniques, including enhanced inventory and quality control, add new dimensions to technology. Key industries—electronics, computers, automotive—are at the forefront of national capability and/or are infusing new capital into plant renovation.

The future holds massive changes in national manufacturing capabilities. Engineering, combined with management practices and capital, provides many new opportunities.

UNDERGRADUATE CONCENTRATIONS IN MANUFACTURING

The Industrial Engineering Program has a manufacturing engineering concentration within its ABET-accredited undergraduate degree, as does the Mechanical Engineering Program.

THE MS (MANUFACTURING ENGINEERING OF ELECTRONIC MATERIALS)

The M.S. program in Manufacturing Engineering of Electronic Materials prepares engineers and scientists working in industry who have diverse academic backgrounds to meet the challenges and unique complexities of the electronic device manufacturing industries. The industries represented include those processing complex materials and those using these materials for the manufacture of complete assemblies of packaged integrated circuits and products. The curriculum develops an understanding of the submicron world of integrated circuits, specialized fabrication techniques, computer integrated manufacturing systems, and exceptional quality control requirements. Upon graduation, students are prepared to use these new skills and to respond to the rapid changes in design, materials, specifications, and fabrication which are found in the electronic industries.

Students enrolled in the M.S. program may elect courses in CAD, lasers, robotics, and other areas. Special to this M.S. degree are the emphases on the processes, materials, facilities designs and CIMS aspects related to electronic materials manufacturing.

Background of Applicants

Applicants for the degree may have an undergraduate degree from any of the engineering disciplines, physics, or chemistry. The curricula are not designed for materials specialists or manufacturing engineers only. It is oriented for other engineers and scientists working in the industry who are unfamiliar with the concepts and skills required to increase productivity, and the reliability and quality of devices.

In order to provide a common basis for the students in the program, certain courses or the equivalent content are required. This may be established by prior formal education examinations or by interviews to review industrial experiences or other training.

Up to six units of these courses may be applied for credit toward the degree, if taken as formal graduate courses and not counted toward an undergraduate degree.

The prerequisite requirements are:
MANUFACTURING ENGINEERING

1. Course in probability and statistics.
2. IE 627 or equivalent.
4. CM 516 - Polymer Organic Chemistry.
5. EL 540 - Solid State Devices & Circuits.

A course in linear programming can be substituted for the system modeling requirement.

Requirements for the Degree Program

The degree requirements are divided as follows:

a. **Core courses** include materials, industrial engineering, and computer integrated manufacturing.

b. **Electives** may be used to obtain concentrations in electronic materials, industrial engineering, mechanical engineering, computer science, and electronics.

c. **Project or Thesis** - An experimental project or thesis is generally required. For part-time students, projects which demonstrate proficiency in handling processing, analytical equipment, and CIMS are substituted for formal laboratory coursework. Full-time students complete theses under direct supervision of the faculty. Oral presentations or project/thesis proposals followed by a second presentation at the completion of the project/thesis are required.

The specific requirements are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 707</td>
<td>3</td>
</tr>
<tr>
<td>MT 709</td>
<td>3</td>
</tr>
<tr>
<td>IE 611</td>
<td>3</td>
</tr>
<tr>
<td>IE 619</td>
<td>3</td>
</tr>
<tr>
<td>CH/MT 625</td>
<td>3</td>
</tr>
<tr>
<td>IE 785</td>
<td>3</td>
</tr>
<tr>
<td>MT/IE 788</td>
<td>3</td>
</tr>
<tr>
<td>MT 996</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
</tr>
</tbody>
</table>

The concepts of just-in-time inventory, real time process control, advantages of robotics, and modifying a production line based upon yield data are introduced in "Statistical Quality Control" and/or "Production Planning and Control".

**Electives**

Electives are chosen in conjunction with assigned academic advisers to meet the career needs of students while providing balance in the education. Elective concentrations are encouraged, emphasizing materials, materials handling, computer aided engineering, quality control and reliability, or robotics in electronics manufacturing. The materials emphasis may be broadened to cover lasers, polymers, and/or optical materials as well as ceramics.

The courses listed below represent the usual selections from which these concentrations are drawn. With the approval of the academic advisers, other courses can be used, or transfer credits or waivers based upon other graduate studies given. For each course shown, the appropriate prerequisites (if any) must be taken.

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 603</td>
<td>Introduction to Electron Microscopy</td>
</tr>
<tr>
<td>MT 720</td>
<td>Advances in Materials Analyses &amp; Characterizations</td>
</tr>
<tr>
<td>IE 606</td>
<td>Work Design &amp; Measurement</td>
</tr>
<tr>
<td>IE 776</td>
<td>Manufacturing Resource Planning</td>
</tr>
<tr>
<td>IE 620</td>
<td>Project Planning &amp; Control</td>
</tr>
<tr>
<td>IE 621</td>
<td>Facility Planning &amp; Design</td>
</tr>
<tr>
<td>IE 642</td>
<td>Robotics Applications</td>
</tr>
<tr>
<td>AM 772</td>
<td>Computer-Aided Design</td>
</tr>
<tr>
<td>EL 617</td>
<td>System Reliability</td>
</tr>
<tr>
<td>EL 618/IE 686</td>
<td>Component Reliability</td>
</tr>
<tr>
<td>EL 645</td>
<td>Integrated Circuit (VLSI) System Design</td>
</tr>
</tbody>
</table>

**Master’s Report**

The M.S. Report, usually 3 units, may be expanded to a 6 unit project by use of some elective credits.

The M.S. Report is to be done in an industrial lab setting whenever possible, with the cooperation of employers and program sponsors.

**OTHER GRADUATE COURSES RELATED TO MANUFACTURING**

The manufacturing engineering orientation of the several engineering programs is described in this section.

**Industrial Engineering**

Manufacturing is one of the natural application areas of industrial engineer, and the entire curriculum can be considered as oriented to this.

The Department's highest priority laboratory growth relates to materials handling, production and assembly, flexible automation, and robotics.

**Illustrative courses in Industrial Engineering related to Manufacturing Engineering are:**

- Work Design and Measurement
- Production Planning and Control
- Project Planning and Control
- Facility Planning and Control
- Manufacturing Processes
- Robotics Applications
- Industrial Safety Engineering
- Manufacturing Resource Planning
- Manufacturing Improvement Curves

**Mechanical and Aerospace Engineering**

The Department of Mechanical and Aerospace Engineering is, by its nature, involved in the design and implementation of man-made systems—machines, vehicles, tools, spacecraft, and reactor vessels. It logically extends to the manufacturing of these systems.
At Polytechnic, mechanical engineering undergraduates may elect a minor in manufacturing through a program which includes courses in:

- Synthesis of Mechanical Systems
- Computer-Aided Design
- Analysis/Design of Machine Elements
- Computer Graphics in CAD
- Instrumentation and Control
- Robotics

Appropriate focus in manufacturing can also be provided at the graduate level by course selection and by theses and dissertation work.

Chemical Engineering

Chemical engineers are involved in the manufacture of a wide variety of materials ranging from semiconductors and plastics to pharmaceuticals and chemicals. Chemical engineering courses which could relate to manufacturing include the following:

CH 625 Design of Clean Rooms
CH 672 Fundamentals of Biochemical Engineering
CH 781-782 Chemical Process Kinetics I & II
CH 921 Polymer Processing

Metallurgy and Materials Science

The Department of Metallurgy and Materials Science is the operation most directly concerned with the materials and techniques of manufacturing. It has the most significant interest in such special programs as electronic materials fabrication.

Existing courses of direct relevance to manufacturing include:

- Mechanical Metallurgy
- Fabrication Technology
- Process Metallurgy
- Metallurgical Failure Analysis
- Ceramic Refractory Materials
- Materials Selection
- Welding Metallurgy
- Powder Metallurgy
- Mechanical Behavior of Materials
- Engineering Materials

Courses in Manufacturing Processes and in Semiconductor Technology are also cross-listed with Transportation & Industrial Engineering and with Electrical Engineering and Computer Science, respectively.

Electrical Engineering and Computer Science

The manufacturing aspects of EE/CS have to do with the control, communications, and computer applications of the manufacturing process. A wide range of courses in computer systems, signal processing, systems theory, control theory, computer graphics, artificial intelligence, data base systems, distributed processing, VLSI design, and software reliability are thus directly relevant.

The following courses illustrate the subjects available:

- Semiconductor Technology
- Systems Reliability
- VLSI Systems Design and Fabrication
- Computer Architecture
- Software Designs and Engineering
- Data-Base Management Systems
- Microprocessors
- Data Communication Networks
- Computer Graphics and Image Processing
- Interactive Computer Graphics
- Artificial Intelligence
- Pattern Recognition

This encompasses both graduate and undergraduate offerings.

FACILITIES AT THE POLYTECHNIC

Metallurgy and Materials Science

The laboratories in metallurgy and materials science include complete mechanical testing, optical and electron microscopy facilities as well as fabrication welding and heat treating equipment.

Computer Aided Engineering

Polytechnic also has a decentralized CAD/CAM facility based upon an IBM 4341. The Industrial Engineering laboratories include three CAD/CAM work stations linked to this facility. Electrical Engineering uses its work station for circuit design and chip layout.

Robotics

The Industrial Engineering laboratories include industrial and educational robots, and a scale materials handling facility.

Industrial Liaison

The nature of the MS (MEEM) program requires visits to industrial laboratories, and cooperative efforts with industry. These have been established.

COURSE DESCRIPTIONS OF THE MS (MEEM)

Only the courses central to the MS (Manufacturing Engineering of Electronic Materials) degree are described in this section. For various other electives, see the section of the catalog for the respective programs within which the electives fall.

MT 707 Thin Films 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.
MANUFACTURING ENGINEERING

MT 709 Integrated Circuits (VLSI) Fabrication Techniques 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 on design rules are pointed out. Prerequisite: MT 608 or Permission of Instructor.

Also listed under EL 464

IE 611 Statistical Quality Control 2:1:0:3
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, attribute sampling plans, introduction to variables sampling plans. (Not open to students who have taken IE 311) Prerequisite: IE 608.

IE 619 Production Planning & Control 2:1:0:3
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 608.

CH 625 Design of Clean Rooms 2:1:0:3

IE 785 Computer Integrated Manufacturing Systems 2:1:0:3
CIMS encompasses all activities from planning and design of a product to its manufacture and shipping. This course will offer several perspectives on the manufacturing system. It will also describe the elements of the system and their interfaces. This conceptual structure will be reinforced by discussion of system planning and performance projection through simulation.

IE/MT 788 Case Studies in Electronics Manufacturing 2:1:0:3
Industrial experts will be invited to lecture on the actual experience in design, design modification, facility layout and “clean” design, yield and product responsibility in the electronic device manufacturing industry. Topics to include: Evolution & Accomplishments of VLSI Yield Management; Metrology in Mask Manufacturing; High Speed Lithography Methods for Submicron Structures; Semiconducto Final Test Logistics & Product Dispositioning Systems; Quality & Reliability Assurance Systems; Identification & Evaluation of Failure Mechanism; and Evolution of Package Design.

MT 996 Report Project for the Degree of Master of Science 3-6 units
Independent project demonstrating professional maturity and graduate-level knowledge completed under guidance of departmental advisor. Report includes critical analysis and interpretation of pertinent literature and should represent worthwhile contribution to the field. Oral final examination and project report required.

FACULTY
(Manufacturing Engineering Program)

George Fischer, Professor of Metallurgy and Head of Metallurgy and Materials Science
B.Met.E., M.Met.E., Polytechnic Institute of Brooklyn
Corrosion and welding metallurgy

William R. McShane, Professor of Transportation and Industrial Engineering; Head of the Department of Transportation and Industrial Engineering; Director of Transportation Training and Research Center
B.E.E., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Transportation and traffic engineering; distribution; PC applications; software development.

Allen S. Myerson, Professor of Chemical Engineering and Head of Chemical Engineering
B.S., Columbia University; M.S., Ph.D., University of Virginia
Crystallization, mass transfer and biochemical engineering

Ephraim Banerjee, Professor of Inorganic Chemistry
B.S., City College of New York; Ph.D., Polytechnic Institute of Brooklyn
Chemistry and physics of crystals, solid state reactions and phase transitions

Irving Cadoff, Professor of Metallurgy
B.M.E., City College of New York; M.M.E., D.Eng.Sc., New York University
Electronic materials; liquid metal embrittlement; thin film epitaxy

Chang Dae Han, Professor of Chemical Engineering and Director of Polymer Science and Engineering Program
B.S., Seoul National University (Korea); M.S., Newark College of Engineering; M.S., New York University
Rheology; polymer processing; process control

Norbert Hauser, Professor of Industrial Engineering
B.M.E., Cooper Union; M.I.E., Eng.Sc.D., New York University
Modeling of manufacturing systems; computer simulation; quality control

Walter Helly, Professor of Operations Research
B.S., Cornell University; M.S., University of Illinois; Ph.D., Massachusetts Institute of Technology
Stochastic modeling; tele- and vehicular traffic; urban systems

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; Director of the Graduate Operations Research Program
B.M.E., City College of New York; M.S., Ph.D., Columbia University
Mathematical programming, optimum design and economic evaluation

Herman Grau, Associate Professor of Industrial Engineering
B.M.E., Polytechnic Institute of Brooklyn; M.I.E., New York University
Methods, work measurement; project management; manufacturing engineering; industrial management

Jovan Mijovic, Associate Professor of Chemical Engineering
B.S., University of Belgrade (Yugoslavia); M.S., Ph.D., University of Wisconsin at Madison
Polymer morphology; fracture properties of polymers; adhesives and composites

Yoahiyuki Okamoto, Professor of Chemistry
B.S., Osaka University of Science and Engineering (Japan); Ph.D., Purdue University
Polymer synthesis, characterization, and applications

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

MANUFACTURING ENGINEERING

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

Ernest Levine, Adjunct Professor of Metallurgy
B.Met.E., Rensselaer Polytechnic Institute; Ph.D., New York University
Electron microscopy

STEERING COMMITTEE FOR MANUFACTURE OF ELECTRONICS MATERIALS

A Presidential Advisory Committee on Electronic Materials Manufacturing, consisting of high-level industrial experts, provides guidance and advice to the degree program and to the departments which oversee it. The members are:

H. Friedrich Vice President, International Business Machines, East Fishkill
S. Weinig President, Materials Research Corporation, Orangeburg, New York
H. Fialkov President, Aleph Null Corporation
R. Nafis President, Grumman Electronic Systems Division
F. Blecher Executive Director, Integrated Circuit Design Division (Bell Labs)

The President, the Vice President for Educational Development, and the heads of the departments which oversee the program attend the meetings of the committee.
MATHEMATICS
AND
STATISTICS

Mathematics is 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.

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 which enable students to prepare themselves for careers in statistics or in a field utilizing statistical theories and techniques. The graduate curriculum is more specialized. Courses, thesis work and informal departmental activities are designed to familiarize students with mathematics in general while they become specialists in their particular areas of 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 bachelor's degree. In addition, a sequence of elective courses in theoretical and applied statistics prepares students for careers in statistics or in fields utilizing statistical theories and techniques.

For science and engineering majors, mathematics provides the theory and methods essential comprehension of the mathematical aspects of their respective fields.

With these objectives, the Department of Mathematics offers 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 one of three courses of study. Students wishing to focus their studies within mathematics itself may elect course of study I, emphasizing abstract mathematics (see page 174). Students, particularly interested in applying mathematics knowledge and techniques to other fields may elect course of study II, emphasizing applied mathematics (see page 175). Students wishing to incorporate computer science into their mathematical training may elect course of study III, computer science option. All three programs provide basic grounding in mathematical knowledge. Details of each follows.

Requirements for the Bachelor of Science Degree

<table>
<thead>
<tr>
<th>Course of Study I</th>
<th>Course of Study II</th>
<th>Course of Study III</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 111-114 or MA 101-104, 153, 154, 217, 223, 333</td>
<td>CS 112, PH 101-103, CM 101, 102, 111, 112</td>
<td>HU 101; and HU 200, SS 104 or IS 140, IS 141</td>
</tr>
<tr>
<td>Two years (or equivalent) of French, German, Russian or Spanish*</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Major specialty†</td>
<td>12, or 14</td>
<td>12, or 14</td>
</tr>
<tr>
<td>Minor specialty‡</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humanities/Social Science electives</td>
<td>26</td>
<td>36</td>
</tr>
<tr>
<td>Free electives</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

*If less than 12 credits are needed, the remaining credits should be taken in the humanities/social science areas.
†Major specialty. Students must elect coherent courses of study in their major field. Three typical selections follow:**
‡Minor specialty. At least twelve credits beyond required courses in any single area of study outside the Department of Mathematics, except for languages, which may include mathematical statistics courses. The sequence must be well integrated and consistent, thereby enabling the student to gain knowledge in an area outside the department of Mathematics. The faculty advisor of the department of interest should be consulted.
**In addition, a program of studies leading to the bachelor of science degree in mathematics (actuarial science) appears in the section titled actuarial science section.

Minor Specialties — To achieve depth of understanding in a field other than mathematics, students are asked to choose a 12-credit sequence from other disciplines. This work must be in addition to courses taken under other categories of the programs, e.g., required courses in physics do not count toward a minor in physics nor do French courses in fulfillment language requirements count toward a minor in French. With the exception of applied statistics and computing courses, all minor courses must be completed outside the department. Education courses are not accepted toward a minor specialty, nor are the first two years of a second foreign language.

Courses of minor specialties are chosen in consultation with advisers. In appropriate cases, advisers for minor
sequences may be from departments other than mathematics. The following are possible minor concentrations:

**Aerospace** AM 111, 112, 311, 312

**Statistics** MA 232, 555, 556, 557

**Biology** LS 105, 115, 106, 116, 103

**Chemistry** CM 122, 123, 161, 162

**Computers** CS 203, 205, 236, 237

**Industrial Engineering** IE 306, 327, and one of IE 311, 319, 321

**Operations Research** IE 300, 327, 328, and one of IE 319, 346, 380

**Management** MG 300, SS 199, IE 252 and either SS 251 or SS 252

**Physics** PH 210, 321, 313, 314

**Psychology** SS 189, 190, 192, 193, 195, 197

**Economics** SS 251, 252, 730, IE 300

**Electrical Engineering** EE 101, 102, 103, 104

**Systems**

**English Literature** HU 211, 212, 222, 241, 251, 258, 262, 272, 295

**French** ML 135, 235, 236, 237, 238

**Transportation** TR 360, 361, 362, 840, 842, 845

**Advanced Placement** — Advanced placement credits may be given for the first year of calculus. Students receiving grades of 4 or 5 on advanced placement examinations in calculus, conducted by the College Entrance Examination Board, may be granted a maximum of eight credits to be applied toward the 128-credit requirement for bachelor's degrees in mathematics.

### ACTUARIAL SCIENCE

The actuarial profession has always been a lucrative field for those at ease with numbers and mathematical theories. Actuarial science combines mathematics, statistics, and business economics. It provides the educational background for a range of careers in business, industry, and government. Typical areas include: insurance, human resources and benefit planning, and contract negotiation.

Actuaries are responsible for calculating premiums on life insurance, casualty insurance, retirement and pension plans. Their duties cover deciding how much money must be set aside periodically to provide future payment of benefits, analyzing sources of earnings under policy contracts to determine proper rates of dividends, and investigating factors related to payments of various types of policies. In life insurance, they consider effects on mortality of physical impairments, hazardous occupations, and other unusual risks; in pension and casualty fields, they are concerned with changing life styles and demographic effects on policy incomes and payments. Actuaries usually play important parts in developing executive policies of companies. Although they cannot operate without thorough knowledge of the mathematical bases of mathematics, they are more business men and women than mathematicians. They explain complicated problems to colleagues and policyholders in clear language.

The development of health, pension, and accident insurance have posed many new problems in mathematical and statistical theory and practical administration. It is largely actuaries who solve these problems. Though not in the life insurance field, actuaries are found in insurance companies. Business and industry provide opportunities for consulting actuaries; actuaries are also employed by federal and state governments.

The profession is not crowded. Large companies, particularly those engaged in writing industrial insurance, group insurance, and pension plans, need large staffs of actuaries. Many people initially trained as actuaries move on to other spheres, particularly the investment, administration, underwriting, accounting, and other executive positions.

In actuarial careers, adequate salaries are paid even during training periods. Later, salaries depend upon responsibilities assumed; average salaries are large.

Qualification is attained by passing examinations required for membership in the Actuarial Society of America or the American Institute of Actuaries. Salaries for actuarial trainees depend on the number of examinations passed. It is anticipated that students in this program are able to take and pass three or four of these examinations before graduating. For this reason, these studies are well-suited to the Cooperative Education Program, especially if students plan to work the year between their junior and senior year.

The program is similar to others in the mathematics department. Course requirements, typical courses of study, and course descriptions for actuarial science follow.

#### Requirements for the Bachelor of Science Degree in Mathematics (Actuarial Science)

<table>
<thead>
<tr>
<th>Credit</th>
<th>MA 101-104, 153, 217, 223</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
<td>CS 111; PH 101-103, CM 101, 102, 111, 112</td>
<td>19</td>
</tr>
<tr>
<td>Credit</td>
<td>HU 101, 200; SS 104, 251, 252</td>
<td>15</td>
</tr>
<tr>
<td>Credit</td>
<td>Two years* (or equivalent) of French, German, Russian or Spanish</td>
<td>12</td>
</tr>
<tr>
<td>Credit</td>
<td>Major specialty: MA 201, 202, 224, 358; AC 301, 302, 401, 402, 501-503, IE 300, 327, 328</td>
<td>38</td>
</tr>
<tr>
<td>Credit</td>
<td>Humanities/Social Sciences elective</td>
<td>3</td>
</tr>
<tr>
<td>Credit</td>
<td>Free electives</td>
<td>18†</td>
</tr>
</tbody>
</table>

* If less than 12 credits are needed, remaining credits should be taken in the HU/SS areas.
† It is suggested that some of these be CS courses.
# 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 112</td>
<td>Programming in Pascal</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing and the Humanities I</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>CS 111</td>
<td>Language course</td>
<td>3</td>
<td>0</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></td>
<td><strong>16</strong></td>
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## Sophomore Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td>MA 113</td>
<td>Calculus IIIa</td>
</tr>
<tr>
<td>MA 154</td>
<td>Elem. Abstract Algebra</td>
</tr>
<tr>
<td>PH 103</td>
<td>General Physics III</td>
</tr>
<tr>
<td>Language course</td>
<td>3</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chemistry Lab. I</td>
</tr>
<tr>
<td>PE 103</td>
<td>Physical Education</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

## Junior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 211</td>
<td>Analysis I</td>
</tr>
<tr>
<td>MA 217</td>
<td>Complex Variables</td>
</tr>
<tr>
<td>MA 223</td>
<td>Intro. to Probability</td>
</tr>
<tr>
<td>SS 104</td>
<td>Contemp. World History</td>
</tr>
<tr>
<td>Minor Specialty</td>
<td>3</td>
</tr>
<tr>
<td>Electives*</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

## Senior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor specialty</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

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></td>
<td>No.</td>
<td>Subject</td>
<td>Cl.</td>
</tr>
<tr>
<td>MA 101</td>
<td>1</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>PH 101</td>
<td>2</td>
<td>General Physics I</td>
<td>3</td>
</tr>
<tr>
<td>CS 112</td>
<td>3</td>
<td>Programming in Pascal</td>
<td>3</td>
</tr>
<tr>
<td>HU 101</td>
<td>4</td>
<td>Writing and the Humanities I</td>
<td>3</td>
</tr>
<tr>
<td>Language courses</td>
<td>5</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>PE 101</td>
<td>6</td>
<td>Physical Education</td>
<td>0</td>
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<td></td>
<td></td>
<td></td>
<td>16</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 | 0   | 1 1/2 | 4/7 | CM 112 General Chemistry Lab. II | 0   | 1 1/2 | 4/7 |
| PE 103 Physical Education | 0   | 2    | 0   | PE 104 Phys. Ed. | 0   | 2    | 0   |
|                |      |               | 15  |     |     |                | 15  |     |     |

## 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   | 0    | 3   |
| Electives | 2   |      |    | Electives | 16  |     |     |
|                |      |               | 17  |     |     |                | 16  |     |     |

## Senior Year

| MA 154 Elem. of Abstract Algebra | 3   | 0    | 3   | Minor specialty* | 3   | 0    | 3   |
| Minor specialty* | 3   |      |    | Electives | 16  |     |     |
| Electives | 16  |      |    | Total credits required for graduation: 128 |

---

*See minor specialty.
**Typical Courses of Study III for the Bachelor of Science Degree in Mathematics (Computer Science)**

### 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>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 General Physics I</td>
<td>3 0 3</td>
<td>PH 102 General Physics II</td>
<td>3 ½ 1½ 4</td>
</tr>
<tr>
<td>CS 112 Programming in Pascal</td>
<td>3 0 3</td>
<td>HU 200 Writing and the Humanities I</td>
<td>3 0 3</td>
</tr>
<tr>
<td>HU 101 Writing and the Humanities</td>
<td>3 0 3</td>
<td>CS 203</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE 101 Physical Education</td>
<td>0 2 0</td>
<td>PE 102 Physical Education</td>
<td>0 2 0</td>
</tr>
<tr>
<td></td>
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### Sophomore Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
<th></th>
<th>Hours/Week</th>
</tr>
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<tbody>
<tr>
<td>MA 103 Calculus III or</td>
<td>3 0 3</td>
<td>MA 104 Appl. Diff. Equations</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH 103 General Physics III</td>
<td>2½ 1½ 3</td>
<td>MA 224 Intro. to Math. Stat.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 223 Intro. Probability</td>
<td>3 0 3</td>
<td>MA 153 Elem. of Linear Algebra</td>
<td>3 0 3</td>
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<td>Language course</td>
<td>3 0 3</td>
<td>Language course</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CS 204</td>
<td>3 0 3</td>
<td>SS 104</td>
<td>3 0 2</td>
</tr>
<tr>
<td>PE 103 Physical Education</td>
<td>0 2 0</td>
<td>PE 104 Physical Education</td>
<td>0 2 0</td>
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### Junior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
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<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td>MA 201 Applied Analysis I</td>
<td>3 0 3</td>
<td>MA 202 Applied Analysis</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA 217 Complex Variables</td>
<td>3 0 3</td>
<td>MA 358 Intro. Numerical Anal.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CS 205</td>
<td>3 0 3</td>
<td>IE 328 Oper. Res. Models II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>IE 327 Operations Res. Models I</td>
<td>3 0 3</td>
<td>CS 206</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 101</td>
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<td>CM 102</td>
<td>2½ 0 2½</td>
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<tr>
<td>CM 111</td>
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<td>CM 112</td>
<td>0 1½ ½</td>
</tr>
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<td></td>
<td>15</td>
<td>Elective</td>
<td>3 0 3</td>
</tr>
<tr>
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<td>18</td>
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</table>

### Senior Year

<table>
<thead>
<tr>
<th></th>
<th>Hours/Week</th>
<th></th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 154 Elem. of Abstract Algebra</td>
<td>3 0 3</td>
<td>CS 308 Electives</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CS 306</td>
<td>3 0 3</td>
<td>CS 308 Electives</td>
<td>13 0 13</td>
</tr>
<tr>
<td>MA 333</td>
<td>3 0 3</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Electives</td>
<td>7 0 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
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</table>

Total credits required for graduation: 128
Typical Course of Study for the Bachelor of Science Degree in Mathematics (Actuarial Science)

**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 101 Calculus I or</td>
<td>4</td>
<td>MA 102 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>Lab. Cr.</td>
<td>4</td>
<td>Cr.</td>
<td>4</td>
</tr>
<tr>
<td>PH 101 General Physics</td>
<td>3</td>
<td>PH 102 General Physics II</td>
<td>3½</td>
</tr>
<tr>
<td>Lab. Cr.</td>
<td>3</td>
<td>Lab. Cr.</td>
<td>1½</td>
</tr>
<tr>
<td>CS 112 Programming in Pascal</td>
<td>3</td>
<td>CS 200 Writing and the Humanities</td>
<td>3</td>
</tr>
<tr>
<td>Lab. Cr.</td>
<td>3</td>
<td>Lab. Cr.</td>
<td>3</td>
</tr>
<tr>
<td>HU 101 Writing and the Humanities</td>
<td>3</td>
<td>HU 102 Writing and the Humanities</td>
<td>3</td>
</tr>
<tr>
<td>Language course</td>
<td>3</td>
<td>Language course</td>
<td>3</td>
</tr>
<tr>
<td>PE 101 Physical Education</td>
<td>0</td>
<td>PE 102 Physical Education</td>
<td>0</td>
</tr>
<tr>
<td>Cl.</td>
<td>16</td>
<td>Cl.</td>
<td>15</td>
</tr>
</tbody>
</table>

**Sophomore Year**

| MA 103 Calculus III or | 3 | MA 104 Appl. Diff. Equations | 3 |
| Lab. Cr. | 3 | Cr. | 3 |
| PH 103 General Physics III | 3½ | PH 200 General Physics II | 3½ |
| Lab. Cr. | 1½ | Lab. Cr. | 3 |
| Language course | 3 | Language course | 3 |
| CM 101 General Chemistry I | 0 | CM 102 General Chemistry II | 2½ |
| Lab. Cr. | 2½ | Lab. Cr. | 0 |
| CM 111 General Chemistry Lab. | 0 | CM 112 General Chemistry Lab. | 1½ |
| Language course | 0 | Language course | ½ |
| PE 103 Physical Education | 0 | PE 104 Physical Education | 0 |
| Cl. | 15 | Cl. | 15 |

**Junior Year**

| MA 201 Applied Analysis I | 3 | MA 202 Applied Analysis | 3 |
| Lab. Cr. | 3 | Cr. | 3 |
| MA 217 Complex Variables | 3 | MA 358 Intro. Numerical Anal. | 3 |
| Lab. Cr. | 3 | Cr. | 3 |
| Lab. Cr. | 3 | Lab. Cr. | 3 |
| AC 301 Actuarial Science Workshop | 1½ | AC 302 Actuarial Science Workshop | 1½ |
| Elective | 1½ | Elective | 2 |
| IE 300 Engineer. Economy | 3 | IE 301 Engineer. Economy | 3 |
| Lab. Cr. | 3 | Lab. Cr. | 3 |
| AC 302 Actuarial Science Workshop | 2½ | AC 303 Actuarial Science Workshop | 2½ |
| Elective | 3 | Elective | 3 |
| | 17 | | 17 |

**Senior Year**

| AC 401 Actuarial Science Workshop | 1½ | AC 402 Actuarial Science Workshop | 1½ |
| Lab. Cr. | 1½ | Lab. Cr. | 1½ |
| AC 502 Actuarial Sci. | 2½ | AC 503 Actuarial Sci. III | 2½ |
| Electives | 3 | Electives | 3 |
| SS 251 Microeconomics | 3 | SS 252 Macroeconomics | 3 |
| Electives | 0 | Electives | 0 |
| | 17 | | 17 |

Total credits required for graduation: 128

*Only 6 language credits are required because foreign languages were begun in high school; they should be taken in freshman year and SS 251, 252 should be taken in sophomore year. Language requirement in sophomore year may then be replaced by 6 other credits of HU/SS in senior year.

**Electives** total 21 credits, of which at least 3 must be in courses with HU/SS labels.
MATHEMATICS AND STATISTICS

GRADUATE PROGRAMS

The Department of Mathematics offers graduate-level courses in 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 master's degrees in abstract mathematics, industrial and applied mathematics and applied statistics. Doctors degrees are offered in abstract mathematics, applied mathematics and applied statistics. Departmental requirements for these degrees are supplemented by certain general requirements for advanced degrees set forth elsewhere in this catalog.

Outstanding students are advised to apply for research fellowships, teaching fellowships or partial tuition remission.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE IN MATHEMATICS

Bachelor's degrees in mathematics are required for admission to this program. Students with degrees in other fields may be admitted, possibly with undergraduate deficiencies, at the discretion of departmental advisers.

Before beginning graduate studies, students are expected to have completed a year's course in advanced calculus. In case of acceptance without these credits, students are asked to take the sequence MA 619-620 at Polytechnic in addition to other requirements listed below for master's degrees.

Thirty-six units are required, including 21 units of required courses. 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 faculty advisers and certification that the work is satisfactory. Students offering only course work must pass comprehensive oral examinations before degrees are awarded. Examinations cover students' programs of study and are scheduled toward the end of the semester in which work is completed.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE (INDUSTRIAL AND APPLIED MATHEMATICS)

The industrial and applied mathematics option is offered to students interested in certain areas of applied mathematics rather than in pure mathematics. By selecting appropriate sequences of courses, students can major in mathematical statistics or in mathematical operations research. Departmental advisers and certification that the work is satisfactory. Students offering only course work must pass comprehensive oral examinations before degrees are awarded. Examinations cover students' programs of study and are scheduled toward the end of the semester in which work is completed.

Bachelor's degrees in some quantitative field, with at least a minor in mathematics, are required for admission to this program. Students who enter without a year's course in advanced calculus are asked to take the sequence MA 619-620 at Polytechnic for which no graduate credit is given. Students who enter without undergraduate courses in linear algebra or complex variables are asked to take one from the graduate program; for each such course successfully completed, three units are allowed toward degrees.

<table>
<thead>
<tr>
<th>No.</th>
<th>Required Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 813</td>
<td>Linear Programming</td>
<td>3</td>
</tr>
<tr>
<td>MA 821</td>
<td>Numerical and Approximate Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MA 853</td>
<td>Probability I</td>
<td>3</td>
</tr>
<tr>
<td>MA 861</td>
<td>Principles of Statistical Inference</td>
<td>3</td>
</tr>
<tr>
<td>Applied electives - chosen from MA 812, 814, 815, 817, 822, 823, 854, 855, 862</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Other electives</td>
<td></td>
<td>9</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>

Regulations governing the thesis option or final examination for degrees are the same as for master's degrees in mathematics.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE (STATISTICS)

Bachelor's degrees are 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. Students may be admitted with undergraduate deficiencies after consulting with departmental advisers. Such students are required to take the courses necessary to remove deficiencies.
Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 519-620 Advanced Calculus</td>
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At least 3 of

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MA 554 Applied Decision Theory</td>
<td>9-12</td>
</tr>
<tr>
<td>MA 555 Design of Experiments</td>
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</tr>
<tr>
<td>MA 556 Correlation and Multivariate Models</td>
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</tr>
<tr>
<td>MA 557 Sampling</td>
<td></td>
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</tbody>
</table>

MA 853 Probability            | 3     |
MA 854 Probability II         | 3     |
MA 861-862 Principles of Stat. Inference I, II | 6     |

Total Units: 27-30

Electives: Project ST 995 (3 units), Thesis ST 997 (6 units) 3-9

Regulations governing the thesis option for final examination for this degree are the same as for master's degrees in mathematics.

The thesis or project option includes an examination of the material by faculty advisers and certification that the work is satisfactory. Students offering only course work must pass comprehensive oral examinations before degrees are awarded. Examinations cover students' programs of study and are scheduled toward the end of the semester in which work is completed.

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE IN MATHEMATICS

With requirements for doctor's degrees primarily qualitative rather than quantitative, all students' programs must have the approval of the guidance committee.

The number of graduate units of course work usually associated with doctoral programs is 72. These are normally selected to form well-balanced programs in one major and two minor fields. One minor field may be outside the Department of Mathematics, selected from such fields as applied mechanics, electrophysics, circuit theory, physics, industrial engineering, industrial management, etc.

Doctoral candidates must pass a qualifying oral examination, which is divided into two parts. Part 1, taken early in the students' careers, covers real and complex variables and algebraic structures; part 2, covering three elective topics, may be taken only after part 1 has been passed. Final examinations, which follow the submission of acceptable dissertations, are also oral.

In addition to 72 units of course work, students must devote at least 24 units to dissertations, reporting original research under the direction of faculty advisers.

Students must satisfy doctoral language requirements in one language (selected from French, German or Russian).

Additional details are contained in brochures which may be obtained from the departmental office.

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REQUIREMENTS FOR THE
DOCTOR OF PHILOSOPHY DEGREE
IN STATISTICS

Within the Department of Mathematics, Polytechnic offers graduate studies in the field of statistics leading to Ph.D. degrees. 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 graduate advisers.

Bachelor's degrees with at least a minor in mathematics, which should include a one-year course in advanced calculus, is required.

<table>
<thead>
<tr>
<th>No.</th>
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<th>Units</th>
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<tbody>
<tr>
<td>MA 630</td>
<td>Elements of Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>MA 703</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MA 621</td>
<td>Real Analysis</td>
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</tr>
<tr>
<td>MA 853,854,855</td>
<td>Probability, Stochastic Processes</td>
<td>9</td>
</tr>
<tr>
<td>MA 861-862</td>
<td>Principles of Statistical Inference</td>
<td>6</td>
</tr>
<tr>
<td>MA 863-864</td>
<td>Multivariate Analysis</td>
<td>6</td>
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<tr>
<td>MA 865-866</td>
<td>Regression and Analysis of Variance</td>
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At least 3 of

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>MA 555 Design of Experiments</td>
<td></td>
</tr>
<tr>
<td>MA 557 Sampling</td>
<td></td>
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</tbody>
</table>

MA 881 Statistical Analysis of Time Series

Electives, approved by departmental adviser 24-27

Dissertation ST 999 (3 units each) 72

Total Units: 96

Students must satisfy the doctoral language requirements in one language (selected from French, German or Russian).

REQUIREMENTS FOR THE 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

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MA 223 Introduction to Probability</td>
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<tr>
<td>MA 224 Introduction to Mathematical Statistics</td>
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Choice of three

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>MA 554 Applied Decision Theory</td>
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<tr>
<td>MA 555 Design of Experiments</td>
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<tr>
<td>MA 556 Correlation and Multivariate Models</td>
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<td>MA 557 Sampling</td>
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</table>

Mathematical Statistics

<table>
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<th>Course</th>
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</thead>
<tbody>
<tr>
<td>MA 861 Statistical Inference I</td>
<td></td>
</tr>
<tr>
<td>MA 862 Statistical Inference II</td>
<td></td>
</tr>
</tbody>
</table>
### Mathematics and 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 882 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

**Mathematical Programming**
- MA 812 Theory of Games
- MA 813 Linear Programming

**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

### Review Courses

**MA 001 Pre-Collegiate Algebra** 2:0:nc
For students who have not taken this subject in preparatory school or who need review work in algebra. Exponents and radicals, factoring and fractions, logarithms, systems of equations, ratios, proportions, variation, quadratic equations, inequalities.

**MA 005 Pre-Collegiate Trigonometry** 2:0:nc
For students who have not taken this subject in preparatory school or who need 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 required recommendation of departmental adviser.

### Undergraduate Courses

**MA 001-002 Principles of Mathematics I, II** each 4:0:4
Logic, sets, mathematical induction, geometry, trigonometry, 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 concepts, 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. Prerequisite: MA 101 or MA 102.

**MA 103 Calculus III** 3:0:3
Solid geometry and vectors, partial derivatives. Multiple integrals. Parametric equations. Prerequisite: MA 102 or MA 112.

**MA 104 Applied Differential Equations** 3:0:3

**MA 111 Calculus Ia** 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 Iia** 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 of matrices. Prerequisite: MA 111 or MA 101 and department's permission.

**MA 113 Calculus IIIa** 3:0:3
Standard operations of calculus of several variables. Partial derivatives. Multiple integrals. Infinite series, power series, uniform convergence, interchange of order of limits, derivatives, integrals, series. Introduction to differential equations. Prerequisite: MA 112 or MA 102 and department's permission.

**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 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, ideals, Euclidean rings, modules, field extension, Galois theory, finite fields, finite division rings. Prerequisite: MA 103.

**MA 161 Introduction of Point Set Topology** 3:0:3
Definitions 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 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 or MA 112.
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, Riemann-Stieltjes integral, uniform and absolute convergence of integrals. Beta, Gamma functions. Prerequisites: MA 103 and MA 104 or MA 113 and MA 114.

MA 211-212 Analysis I, II each 3:0:3

MA 217 Complex Variables 3:0:3
Functions of complex variables, derivatives, Cauchy-Riemann equations, integrals, Cauchy integral theorem, power series, residue theorem, conformal mapping, Schwarz-Christoffel transformation. Prerequisites: MA 103 and MA 104 or MA 113 and MA 114.

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
Descriptive statistics computed from data; means, variances, histograms. Applications of binomial, normal, t, and chi square distributions. Statistical tests. Confidence intervals. Simple regression and correlation. Prerequisite: MA 102.

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 223.

MA 239 Mathematical Modeling 3:0:3
The construction of a Mathematical Model. Simple examples: Discrete and Continuous Models, Deterministic and Probabilistic Models, Linear and Nonlinear Models. Detailed examples from mechanical vibrations, population dynamics, theory of epidemics, graph theory, traffic flow, optimization theory, etc. Testing the validity of a model. Prerequisites: MA 103, MA 104, and MA 233 or equivalent.

MA 260 Vector Analysis and Partial Differential Equations 4:0:4

MA 333 Partial Differential Equations 3:0:3
Fourier series and integral. Heat, wave and La Place differential equations. Dirichlet and Neumann problems. Legendre polynomials and Bessel functions, some numerical techniques. Prerequisites: MA 103 and MA 104.

MA 341 Discrete Computational Structures I 3:0:3
Basic concepts of Combinatorics and Linear Graph Theory. Logic and Proof Techniques. Relations and Functions. Boolean Algebra and other Algebraic Structures. Prerequisite: junior status or permission of instructor.

MA 342 Discrete Computational Structures II 3:0:3
Extends Graph Theory to Network Algorithms and covers material from Finite State Machines, Computability, and Formal Languages. Introduces basic concepts of Queuing Theory.

MA 359 Introductory Numerical Analysis 3:0:3

MA 365-386 Reading Seminar in Mathematics I, II 3:0:3
Reading, study and investigation of selected topics in mathematics. Problem discussions and presentations by participating students. Prerequisite: department adviser's permission.

Additional offerings in the area of statistics may be found under 500-number courses.

ACTUARIAL SCIENCE

AC 301 Actuarial Science Workshop I 1½:1½:2
Applications of analysis, linear algebra and probability to actuarial science. Review and extension of concepts skinned in prerequisite courses. Prerequisites: MA 104 or MA 114, MA 153, MA 223.

AC 302 Actuarial Science Workshop II 1½:1½:2
Application of statistics, operations research and numerical methods to actuarial science. Prerequisites: AC 301, MA 224, IE 327. Corequisites: IE 328, MA 358.

AC 401 Actuarial Science Workshop III 1½:1½:2

AC 402 Actuarial Science Workshop IV 1½:1½:2
Workshops on life contingencies. Prerequisites: AC 401, AC 502. Corequisite: AC 503.

AC 501 Actuarial Science I — Mathematics of Compound Interest and Introduction to Life Contingencies 2½:0:3
Measurement of interest, elementary and general annuities; amortization schedules; sinking funds; bonds and other securities; introduction to life contingencies. Prerequisites: MA 103, MA 104, MA 223.

AC 502 Actuarial Science II — Single Life Functions 2½:0:3
Life annuities; insurance premiums; reserves; expenses; combined benefits; and population theory. Prerequisite: AC 501.

AC 503 Actuarial Science III — Multi-Life and Multi-Decrement Functions 2½:0:3
Joint life status; general multi-life statuses, contingent functions; reversionary annuities; multiple decrement tables; secondary decrements, a generalized model. Prerequisite: AC 502.
GRADUATE COURSES

MA 503 Mathematical Logic 2 ½:0:3
Propositional logic, quantification theory, independence, completeness, computability, decidability. Topics to be chosen from: Godel's theorems on completeness, incompleteness, and consistency; Turing machines; recursive functions; switching circuits; Hilbert's tenth problem; lattices and boolean algebra. (Acceptable for graduate credit in the Mathematics Dept.)

MA 505-506 Foundations of Mathematics 2 ½:0:3
Propositional logic, quantification theory, relations, functions, cardinals, ordinals, cardinal arithmetic, axiom of choice, filters and ultrafilters. Topics to be chosen from: Lattices and boolean algebra; nonstandard analysis, quantum logic; multivalued logic; model theory; ordinal arithmetic; measurable cardinals. (Acceptable for graduate credit in the Mathematics Dept.)

MA 531-532 Applied Mathematics in Engineering and Science I, II each 2 ½:0:3

MA 535 Vector and Tensor Analysis 2 ½:0:3
Vector analysis in three dimensional space, integral theorems, applications to potential theory. Tensor algebra, tensor calculus, fundamentals of Riemannian 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 2 ½:0:3
Mathematical models, mathematical reasoning, primitives of naive set theory, inductive and recursive procedures, functions, relations, orderings, introduction to graph theory, counting and algorithm analysis, introduction to algebraic structures. MA 541 prerequisite: permission of adviser. MA 542 prerequisite: permission of adviser.

MA 551 Applied Statistics I (Data Analysis) 2 ½:0:3
Treatment of statistical methods and application to analysis of data, to fitting of functions to data. Estimation of population parameters, t-tests, chi-square tests, rank tests, analysis of variance, linear and non-linear regression, spectral analysis. Prerequisite: MA 102 not accepted for graduate credit in Department of Mathematics.

MA 552 Applied Statistics II (Experimental Design) 2 ½:0:3
Statistical principles useful in designing comparative and descriptive experiments and their applications. Randomized block designs, latin square, factorial, saturated, response surface designs, sequential experimentation. Prerequisite: MA 551 or MA 232.

MA 554 Applied Decision Theory 2 ½:0:3
Principles of statistical decision procedures; introduction to utility theory, minimax. Bayes strategies. Applications to problems in engineering, science, management. Prerequisite: MA 224 or MA 562.

MA 555 Design of Experiments 2 ½:0:3
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 experiments, surface fitting designs. Prerequisite: MA 224 or MA 232.

MA 558 Correlation and Multivariate Models 2 ½:0:3
Treatment of experimental data involving various types of measurements per individual. Regression and correlation. Simple multiple and partial correlations. Problems of discrimination and classification; elements of factor analysis. Applications to analysis and interpretation of data. Prerequisite: MA 224 or MA 232.

MA 557 Sampling 2 ½:0:3
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 nonsampling aspects of survey investigations. Prerequisite: MA 224 or MA 232.

MA 558-559 Topics in Geometric Optimization I, II each 2 ½:0:3
Topics to be chosen from: search techniques, geometric distributions, packings and coverings, arrangements and spreads, curve fittings and pattern recognitions, mathematical stereology and extremum problems. MA 558 prerequisites: MA 103 and MA 104. MA 559 prerequisites: MA 103 and MA 104.

MA 561 Elements of Probability 2 ½:0:3
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 2 ½:0:3
Estimation, confidence limits, tests of hypothesis, regression analysis, Applications to engineering problems. (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 2 ½:0:3
Solutions of ordinary differential equations. Applications to geometry and physics. Oscillation theory. Introduction to geometric theory, elementary critical points. Prerequisite: MA 103 and MA 104.

MA 570 Introductory Geometry 2 ½:0:3
First course in modern geometry. Surface areas, volumes, transformation groups, convexity, Minkowski spaces, elementry metric spaces. Prerequisite: MA 113 or MA 103, and MA 153.

MA 575 Introduction to Differential Geometry 2 ½:0:3
Differential geometry in the plane, theory of curves, surfaces, introduction to Riemannian geometry. Prerequisites: MA 103 and MA 153 or equivalent.

LOGIC AND FOUNDATIONS

MA 603 Symbolic Logic 2 ½:0:3
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 3 ½:0:4½
Elements of abstract spaces and structures with applications to specific modern problems in ordinary and partial differential equations, probability and statistics, linear programming. 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  Topics in Complex Variables each 2 V.:0:3
Introduction to informal axiomatic set theory: relations, functions, the axiom of choice, well ordering, Zorn’s lemma, transfinite recursion, cardinal numbers, ordinal numbers, cardinal arithmetic, ordinal arithmetic. Introduction to mathematical logic: propositional calculus, first-order logic, first-order recursive arithmetic. Topics to be chosen from the following: Boolean algebra and lattices, touring machines, computability, non-standard analysis, model theory. Prerequisite: calculus.

ANALYSIS

MA 618-620  Advanced Calculus I, II each 2 V.:0:3

MA 621  Real and Complex Analysis I 2 V.: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, Lebesgue’s theorem, product measure, Fubini theorems. Prerequisite: MA 620 or equivalent.

MA 622  Real and Complex Analysis II 2 V.:0:3
Rigorous development of theory of functions of complex variables. Complex number systems, 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 2 V.: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. Hausdorff measure, measures in functional spaces. MA 625 prerequisite: MA 626 or instructor’s permission. MA 626 prerequisite: MA 625.

MA 630  Elements of Complex Variables 2 V.:0:3
Analytic functions of complex variables. Complex numbers, differentiation and integration. Cauchy’s theorems, power series. Evaluation of integrals by residues. Conformal mapping, Schwarz-Christoffel transformations. Prerequisites: MA 103 and MA 104. (Not open to students who have taken MA 217.)

MA 637-638  Topics in Complex Variables each 2 V.: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 622.

MA 645  Theory of Ordinary Differential Equations 2 V.: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 2 V.:0:3

MA 649-650  Topics in Ordinary and Partial Differential Equations 2 V.: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 659  Calculus of Variations 2 V.: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 2 V.: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 661.

MA 683-684  Special Topics in Functional Analysis each 2 V.: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 682. MA 684 prerequisite: MA 683.

ALGEBRA AND NUMBER THEORY

MA 703  Linear Algebra 2 V.: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 2 V.:0:3
Basic algebraic structures, groups, rings, fields, integral domains, ideals, modules. Extension of fields, Galois theory. Prerequisite: MA 620 or equivalent.

MA 706  Linear and Modern Algebra II 2 V.:0:3

GEOMETRY AND TOPOLOGY

MA 715-716  Advanced Topics in Algebra each 2 V.: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.
MATHEMATICS AND STATISTICS

MA 755-758 Topology I, II each 2½:0:3
Topological spaces, compactness, connectedness, continua, extension theorems, metrization theorems. Simplexes, simplicial topology and applications, fixed-point theorems, graphs and networks, homology and co-homology theory, introduction to Morse theory. MA 755 prerequisite: MA 620 or equivalent. MA 756 prerequisite: MA 755.

MA 775-776 Manifolds — Geometry and Differential Topology I, II each 2½:0:3

MA 785 Selected Topics in Geometry 2½:0:3
Integral geometry, combinatorial geometry, transformation groups, Lie groups and algebras, algebraic geometry, convex polytopes and geometry of numbers. Prerequisites: MA 751 and instructor's approval.

MA 788 Selected Topics in Topology 2½:0:3
Complex spaces (several complex variables), calculus of variations in the large (Morrey theory), global differential geometry, differential topology, homotopy theory. Prerequisite: MA 751 and instructor's approval.

APPLIED MATHEMATICS

MA 801-802 Special Topics in Applied Mathematics I, II each 2½:0:3

MA 804 Calculus of Finite Differences 2½:0:3
Discussion of various difference equations, generating functions, analogies with differential equations. Introduction to stability theory, mixed differential difference equations, applications to mathematical physics, adaptability of digital computers to solution of difference equations. Prerequisites: MA 103 and MA 104.

MA 812-817 Listed below under Probability, Statistics, Operations Research

MA 819-820 Theory of Approximation each 2½:0:3

MA 821 Numerical Analysis 2½:0:3

MA 822 Numerical Solution of Partial Differential Equations 2½:0:3

MA 823 Special Topics in Numerical Analysis 2½:0:3

MA 825 Numerical Linear Algebra 2½:0:3

MA 833 Partial Differential Equations of Mathematical Physics 2½:0:3

MA 835 Potential Theory 2½:0:3
Theory of potential and application to problems. Newtonian potential, expansion of potential in series of spherical harmonics, properties of harmonic functions, relation of potential to theory of functions, inversions, Green's function, Poisson's integral. Prerequisite: MA 202 or 212 or MA 820.

MA 836 Applied Complex Variables 2½:0:3
Brief review of important characteristics of analytic functions. Use of conjugate functions in solution of two-dimensional potential problems. Study of conformal mapping with emphasis on Schwarz-Christoffel transformation and its applications. Prerequisite: MA 830 or MA 622.

MA 837 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 hermitian pencils. Prerequisites: MA 103 and MA 104. Also listed under EL 513.

MA 838 Linear Algebra and Differential Equations 2½:0:3
Basic theory of linear algebra and its application to systems of ordinary differential equations, method of adjoints, series solutions, equations with periodic coefficients, stability theory, applications to nonlinear systems. Prerequisites: MA 103 and MA 104.

MA 839 Introduction to Functional Analysis 2½:0:3
Study of operations on metric, Banach and Hilbert spaces. Application of functional analysis concepts to integral and differential operators of mathematical physics, spectral theory, special topics in nonlinear functional analysis. Prerequisite: MA 838 or equivalent.

MA 841-842 Integral Equations I, II each 2½:0:3
MA 844 Optimal Control Theory* 2 1/2:0 3
Optimal control problems for deterministic systems with various constraints. Solutions for both continuous and discrete-time systems using maximum principle and dynamic programming. Hamilton-Jacobi theory as applied to synthesis problem. Prerequisite: EL 723.

Also listed under EL 823

MA 846 Fourier and La Place Transforms 2 1/2:0 3
Application of transform methods of partial differential equations of mathematical physics. Includes introduction to Wiener-Hopf technique. Prerequisites: MA 631 or MA 620 or MA 630.


PROBABILITY, STATISTICS, OPERATIONS RESEARCH

MA 812 Theory of Games 2 1/2:0 3

MA 814 Integer Programming 2 1/2:0 3

Also listed under IE 631

MA 815 Theory of Queues 2 1/2:0 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 816-817 Graph Theory I, II each 2 1/2:0 3
Graphs and subgraphs, connectivity, trees and graph, planarity, embeddings, n-connectivity and edge-connectivity, Hamilton graphs, matchings, factorization and covering, graphs and groups, graph isomorphism and reconstruction, 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 prerequisite: MA 816.

MA 818-820 Nonlinear Programming 2 1/2:0 3

Also listed under IE 632

MA 821-823, 825-833, 835-839, 841-842, 844, 846, 848, listed above under Applied Mathematics.

MA 853 Probability I 2 1/2:0 3
Probability for events, distribution of random variables, joint distributions, transformations. Prerequisites: MA 103 and MA 104, MA 223 or equivalent.

MA 854 Probability II 2 1/2:0 3

MA 855 Stochastic Processes 2 1/2:0 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 2 1/2:0 3

MA 863-864 Multivariate Analysis I, II each 2 1/2:0 3

MA 865-866 Regression and Analysis of Variance I, II each 2 1/2:0 3

MA 867 Nonparametric Methods in Statistics 2 1/2:0 3
Statistical methods not bound by assumptions. Not 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, limiting distributions, large-sample properties of tests. Prerequisite: MA 224 or MA 562 and IE 608.

MA 868 Sequential Statistical Methods 2 1/2:0 3
Fixed sample size vs. sequential statistical procedures Wald's sequential probability ratio test. OC and ASN functions, optimal properties, approximation, generalization. Sequential estimation, optimal stopping, sequential design of experiments. Application to sampling inspection, inventory and control problems. Prerequisite: MA 224 or MA 562/IE 608.

MA 869-870 Advanced Statistical Inference I, II each 2 1/2:0 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. MA 869 prerequisite: MA 862. MA 870 prerequisite: MA 869.

MA 871-872 Advanced Probability I, II each 2 1/2:0 3
MA 855-956 Selected Topics in Advanced Mathematics I, II each 3 1/2:0:4 1/2
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 957 Thesis for Degrees 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 advisor required. Reregistration fee, any part: 3-unit charge. Prerequisite: degree status.

MA 959 Dissertation for Degrees 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-unit charge. Prerequisite: degree status and qualifying examination.

ST 995 Project for Degrees 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 the 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 the 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-unit 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 2231). A list of such courses follows.

MA 153 Elements of Linear Algebra 3 cr.
MA 154 Elements of Abstract Algebra 3 cr.
MA 194 History of Mathematics 3 cr.
MA 223 Introduction to Probability 3 cr.
MA 224 Introduction to Mathematical Statistics 3 cr.
MA 231-232 Statistical Methods I, II 3 cr. ea.
MA 238 Applied Probability 3 cr.
MA 531-532 Applied Mathematics in Engineering and Science ea.
MA 541-542 Fundamental of Discrete Mathematics I, II 3 cr.
MA 558-559 Topics in Geometric Optimization I, II 3 cr.
MA 561 Elements of Probability 3 cr.
MA 562 Elements of Mathematical Statistics 3 cr.

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 J. Terzouli, Emeritus Professor of Mathematics and Administrative Officer
B.S., Brooklyn College; M.S., New York University
Probability, statistics

Emerich 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

Erwin Lutwak, Professor of Mathematics
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn
Convexity
MATHEMATICS AND STATISTICS

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

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

Roeve 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.), Farleigh Dickinson University; D.Sc. (Hon.), Polytechnic Institute of New York
Network theory; graph theory

Clifford W. 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

Edward Y. Miller, Professor of Mathematics
B.A., University of Pennsylvania; M.A., Ph.D., Harvard University
Topology

Paul F. Pickel, Professor of Mathematics
B.S., Ph.D., Rice University
Infinite groups, ring theory, algebraic topology, optimization

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 Weill, Professor of Mathematics
Lie. Math., Dr.Sc., University of Paris (France); Ph.D., University of Southern California
Complex analysis; global analysis; partial differential equations

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

Joel Rogers, Associate Professor of Mathematics
B.S., Ph.D., Massachusetts Institute of Technology
Partial differential equations; fluid mechanics; numerical methods

Lesley Sibner, Professor of Mathematics
B.S., CCNY; M.S., Ph.D., New York University
Partial differential equations; global analysis

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.
MECHANICAL AND AEROSPACE ENGINEERING

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 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/fluid/energy fields, 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 applications of such principles to the challenges of their profession. The sophistication of aerospace systems is such that students must necessarily master some of the more powerful analytic techniques to evolve efficient designs. 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 emphases are primarily on principles and concepts in fundamental and basic sciences.

In the junior and senior years, professional courses include fluid mechanics, solid mechanics, guidance and control, dynamics, flight mechanics, propulsion, and design.

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

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 of mechanical engineering.

A valuable feature of the program is the availability of technical electives in each of the last four semesters. In consultation with faculty advisers, students may construct a minor in one of many technical areas outside traditional mechanical engineering. Alternatively, students 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 recognized 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>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>MA 101 Calculus I</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH 101 Introductory Physics I</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CS 102 Intro. to Programming</td>
<td>2 0 2</td>
</tr>
<tr>
<td>HU 101 Writing and the Humanities</td>
<td>3 0 3</td>
</tr>
<tr>
<td>SS 104 Main Themes in Contemp. World Hist.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE 101 Physical Education</td>
<td>0 2 0</td>
</tr>
</tbody>
</table>

### Sophomore Year

<table>
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<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
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<tr>
<td>No. Subject</td>
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<tr>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
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<tr>
<td>PH 102 Introductory Physics II</td>
<td>3½ 1½ 4</td>
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<tr>
<td>AM 111 Mechanics I</td>
<td>3 0 3</td>
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<tr>
<td>HU 200 Writing and the Humanities II</td>
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<tr>
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<tr>
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### Junior Year

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<th>Hours/Week</th>
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<tbody>
<tr>
<td>No. Subject</td>
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<tr>
<td>MA 103 Calculus III</td>
<td>3 0 3</td>
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<td>PH 103 Introductory Physics III</td>
<td>2½ 1½ 3</td>
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<tr>
<td>CM 101 General Chemistry I</td>
<td>2½ 0 2½</td>
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<td>CM 111 General Chemistry Lab. I</td>
<td>0 1½ ½</td>
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<tr>
<td>AM 101 Graphics</td>
<td>1 3 2</td>
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<tr>
<td>AM 112 Mechanics II</td>
<td>3 0 3</td>
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<tr>
<td>Hum./Soc. Sci.* or HU 110</td>
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<tr>
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### Senior Year

<table>
<thead>
<tr>
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<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>AM 233 Fluids II</td>
<td>3 0 3</td>
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<tr>
<td>AM 261 Vibrations</td>
<td>3 0 3</td>
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<tr>
<td>AM 281 Advanced Stress Analysis I</td>
<td>2½ 1½ 3</td>
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<td>AM 312 Mechanics of Flight II</td>
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<td>AM 343 Aircraft Design II</td>
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<td>Free Elective*²</td>
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</table>

### Total credits required for graduation: 136

*Free electives are subject to departmental advisors' approval.

*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.

*Approved technical electives are listed as follows: AM 234, AM 262 and AM 351. The choice of any of the above electives or possible other technical electives must be accompanied by a departmental advisor's approval.

*Requirements in humanities and social sciences — the student must take HU 101, HU 110, 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 noncredit writing course before taking HU 101 (or HU 103) and HU 110.

At least 18 of the credits students select in the humanities and social sciences must meet the requirements of the Accreditation Board for Engineering and Technology (ABET). These credits may not include skills-oriented courses such as technical writing, public speaking, or English as a second language. Courses in literature, foreign languages, history, economics, and others are acceptable. Students should consult their advisers to ensure that these criteria are met.

In addition, students should select an area of concentration (such as literature, communications, the arts, or philosophy and comparative religions in the Department of Humanities or economics, history, anthropology or psychology in the Department of Social Sciences) and elect a number of courses in this concentration, in consultation with departmental advisors. 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. 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.
## Typical Course of Study for the Bachelor of Science Degree in Mechanical Engineering

### Freshman Year

<table>
<thead>
<tr>
<th>Semester</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<td>CM 101 General Chemistry I</td>
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### Sophomore Year

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<th>Lab.</th>
<th>Cr.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tr>
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<td>MA 104 Applied Diff. Equations</td>
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<td>PH 103 Introductory Physics III</td>
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<td>3</td>
<td>MT 302 Metallurgy for Engineers</td>
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<tr>
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<td>2½</td>
<td>AM 112 Mechanics II</td>
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<tr>
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<td>CM 112 General Chemistry Lab. II</td>
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<td>1½</td>
<td>1½</td>
<td>AM 121 Mechanics of Materials</td>
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<td>AM 101 Graphics</td>
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<td>HU 110 or Hum./Soc. Sci.*</td>
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<td>PE 104 Physical Education</td>
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### Junior Year

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<th>Cr.</th>
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<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<tr>
<td></td>
<td>MA 333 Partial Diff. Equations</td>
<td>3</td>
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<td>AM 202 Thermodynamics II</td>
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<td>AM 232 Fluids II</td>
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<td>AM 231 Fluids I</td>
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<td>AM 252 Dynamic System Response</td>
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<td>AM 301 Synth. of Mech. Systs.</td>
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<td>AM 302 Anal./Design of Mach. Elem.</td>
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<tr>
<td></td>
<td>AM 351 ME Laboratory I</td>
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<td>AM 331 Comp. Meth. in Design</td>
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### Senior Year

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<th>Cr.</th>
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<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
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<td>AM 203 Heat Transfer</td>
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<td>AM 204 Energy Transfer Design</td>
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<td>AM 261 Vibrations</td>
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<td>AM 272 Stress Anal. of Mech. Comp.</td>
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<td>AM 321 Instrumentation &amp; Control</td>
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<td>AM 362 ME Project</td>
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See footnotes on previous page.

*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 adviser, 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 students may complete all requirements in eight years without summer work.

MECHANICAL AND AEROSPACE ENGINEERING

The first four years consist of the basic mathematics, humanities, social sciences, physical sciences and engineering sciences contained in the freshman-sophomore years of the full-time program. In the remaining four years, the program consists of advanced undergraduate engineering courses, these four years being offered on an alternating basis. The fifth and sixth years are interchangeable as are the seventh and eighth.

Course of Study for the Evening Program in Mechanical Engineering

<table>
<thead>
<tr>
<th>First Year</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
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<td>101 Calculus I</td>
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<td>103 Calculus III</td>
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<tr>
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<td>101 General Chemistry I</td>
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<td>111 General Chemistry Lab. I</td>
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<td>Fourth Year</td>
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<tr>
<td>AM</td>
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<td>333 Partial Diff. Equations</td>
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<tr>
<td>AM</td>
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<td>331 Comp. Meth. in Design</td>
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</tbody>
</table>

Total credits required for graduation: 136

*Fifth and sixth years are interchangeable.
†Seventh and eighth years are interchangeable.


**MECHANICAL AND AEROSPACE ENGINEERING**

**GRADUATE PROGRAM**

Programs of study are offered leading to the degrees of master of science, engineer, and doctor of philosopher in mechanical engineering, in aeronautics and astronautics, and in applied mechanics. In mechanical engineering, students may specialize in either (1) the mechanical analysis and design option or in (2) the thermal/fluids/energy option. Bachelor's degrees in mechanical, aerospace, civil or chemical engineering are 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>
<thead>
<tr>
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<th>Course Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>AM 601-02</td>
<td>Stress Analysis I &amp; II</td>
<td>6</td>
</tr>
<tr>
<td>AM 603-04</td>
<td>Elasticity I &amp; II</td>
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</tr>
<tr>
<td>AM 651-52</td>
<td>Advanced Dynamics I &amp; II</td>
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<tr>
<td>AM 653-54</td>
<td>Dynamics of Machines; Mechanical Vibrations</td>
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</tr>
<tr>
<td>AM 971-72</td>
<td>Seminar in Mechanical and Aerospace Engineering</td>
<td>12</td>
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</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>
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<th>Course Code</th>
<th>Course Title</th>
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<tr>
<td>AM 701</td>
<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>Principles of Fluid Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>AM 971-72</td>
<td>Seminar in Mechanical and Aerospace Engineering</td>
<td>12</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>
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<tbody>
<tr>
<td>AM 601-602</td>
<td>Stress Analysis I, II</td>
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<td>AM 603-04</td>
<td>Elasticity I &amp; II</td>
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</tr>
<tr>
<td>AM 613-14</td>
<td>Theory of Plates and Shells</td>
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</tr>
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<td>AM 651-52</td>
<td>Advanced Dynamics I &amp; II</td>
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<td>Electives</td>
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B1 — Mechanical Engineering (Thermal/Fluids/Energy Option)

Core Courses (B) 9

Select 12 additional units from

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<tr>
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<td>AM 711</td>
<td>Convective Heat Transfer</td>
<td></td>
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<td>Electives</td>
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</table>

In each of the above master's degree programs students 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 advisor 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 students in departmental courses (including thesis or project) at Polytechnic.

The department limits to nine the total of transfer, reading (guides studies), and validation credits which can be offered toward master's degrees. The certification of validation credits is administered by the departmental graduate advisors.

To obtain any graduate degree or certificate, a student must have 3.0 grade point averages or better in all graduate courses and B or better averages in all guided studies (readings, project, thesis, dissertation). Additionally, students must establish overall B averages in those departmental courses submitted in partial fulfillment of degree requirements. All courses submitted for degrees

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Either the core courses or the electives must include AM 651-52, Advanced Dynamics I & II.
must have been completed within the four-year period prior to the awarding of degrees.

**REQUIREMENTS FOR THE ENGINEER DEGREE**

Master's degrees in mechanical, aerospace, civil or chemical engineering which meet one of the department specialization area requirements are generally required. Applicants with master's degrees not meeting these requirements may be conditionally admitted with deficiencies as evaluated by a departmental graduate adviser. All candidates must complete programs of study of at least 36 units beyond master's degrees as approved by an appropriate departmental graduate adviser. These programs of study normally include at least 24 units of work within the department; part of this work includes a project of 6 but not more than 12 units. Course work may be substituted for the project if applicants' backgrounds include 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 degrees or certificates, students must have 3.0 grade point averages or better in all graduate courses and B or better averages in all guided studies (readings, project, thesis, dissertation).

**REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE**

Students interested in the Ph.D. program are required to consult as soon as possible with department graduate advisers regarding eligibility to the qualifying examinations and other regulations.

Master's degrees in mechanical, aerospace, civil or chemical engineering which meet one of the department's area requirements are generally required. Applicants with degrees not meeting these requirements may be admitted with credit for previous work as evaluated by a departmental graduate adviser.

In order to enroll in a doctoral program of study, each candidate must pass a set of qualifying examinations in certain basic fields. Upon passing these examinations, a guidance committee is formed, and the candidate may then register for dissertation research.

All candidates for the Ph.D. must complete a minimum of 36 units of approved courses beyond master's degrees in addition, registration for a minimum of 24 units of dissertation research is required 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 degrees.

**MECHANICAL AND AEROSPACE ENGINEERING**

**UNDERGRADUATE COURSES**

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<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AM 112</td>
<td>Mechanics II</td>
<td>3:0:3</td>
<td>Three-dimensional vector treatment of the kinematics and kinetics of particles and rigid bodies using various coordinate systems. Newton's laws, work, energy, impulse, momentum, conservative force fields, impact. Rotation and plane motion of rigid bodies. Prerequisite: AM 111.</td>
</tr>
<tr>
<td>AM 121</td>
<td>Mechanics of Materials</td>
<td>3:0:3</td>
<td>Basic principles of stresses and strains of members subjected to direct force, torsion and bending. Deflections of beams. Statically determinate and indeterminate problems. Column stability. Prerequisite: AM 111 or AM 115 or AM 118. Also listed under CE 202</td>
</tr>
<tr>
<td>AM 201</td>
<td>Thermodynamics I</td>
<td>3:0:3</td>
<td>Properties of pure substances; concepts of work and heat; closed and open systems. The fundamental laws of thermodynamics: entropy and entropy production; Carnot and Clausius statements; heat engines, refrigerators, heat pumps; efficiencies, coefficients of performance. Prerequisites: MA 104 and PH 102.</td>
</tr>
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MECHANICAL AND AEROSPACE ENGINEERING

AM 202 Thermodynamics II 3:0:3

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. Applications of first and second laws of thermodynamics to design and evaluation of energy conversion cycles. Detailed heat exchanger or energy system design required of students. Prerequisite: AM 202 and AM 203.

AM 211 Statistical Thermodynamics 3:0:3
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. Calculations 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 approaches to solutions of engineering problems in air conditioning and refrigeration. Senior elective. Prerequisite: AM 201.

AM 213 Transport Processes 3:0:3

AM 231 Fluids I 3:0:3
Fluids; kinematics, hydrostatics, thermodynamics. Derivations of continuity, momentum and energy equations. Flux concepts and introduction to phase and chemical equilibrium. Prerequisite: AM 203.

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

AM 242 Rocket Propulsion 3:0:3
Development and design of rocket engines. Basic principles of mechanics, thermodynamics, aerodynamics and combustion reviewed. Propellants, rocket engine elements (solid and liquid), heat transfer, cooling accessories, 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, turbines) including design principles and operation of turbomachines. 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. Projectiles 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 systems for simple element behavior to complex systems. Modeling and formulation of system equations. Analogies and computer simulations introduced. Generalized _first- and second-order dynamic systems subject to various excitations. Prerequisite: AM 112 or AM 115 or AM 117.

AM 256 Vibration 3:0:3

AM 257 Noise and Acoustics 3:0:3

AM 263 Advanced Vibrations 3:0:3

AM 271 Fundamentals of Stress Analysis I 3:0:3
Stress, equilibrium equations, strains, compatibility conditions, stress strain relations, superposition, strain energy. Bending of beams: unsymmetric bending of arbitrary section beams, bending stresses, deflections, shears stresses on thin-walled section beams, shear center. Prerequisite: MA 104 and AM 121.

AM 272 Stress Analysis of Mechanical Components 3:0:3

AM 273 Fundamentals of Stress Analysis II 2½:1½:3
Torsion of thin-walled open and closed section beams. Membrane and hydrodynamic analogies. Bredt's formula, multi celled cross sections. Strain energy, Castigliano's theorems. statically indeterminate beams, frames, rings. Laboratory experimental stress analysis, strain gages, brittle coating, photoelasticity, analogies. Prerequisite: AM 271.
AM 281 Advanced Stress Analysis 1 2:3:1
Elastic and inelastic buckling of columns, frames, plates, shells, effective width, sheet-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, instaneous 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, springs, screws, shafting, belt and gear systems. Fundamentals of friction, wear, boundary, hydrodynamic lubrication. Engineering principles from several disciplines applied to individual problems. Prerequisites: 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 airfoil 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 instrumentation components. Active and passive transducer elements for steady and non-steady temperature, pressure, displacement, acceleration, measurements, 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. Uses of classical and transform methods for transient and steady-state solutions. Prerequisite: AM 321.

AM 331 Computational Methods in Computer-Aided Design 2:3:3
Introduction to computing hardware peripherals used for computer aided design, and to computational methods used in design processes. Laboratory sessions reinforce classroom instruction through use of remote terminals and mainframe computer, microcomputers 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
Robotics and the relevant fields related to robot design and operation. Kinematic problems peculiar to robotic construction, control consideration, power sources, and the need for sensory equipment and intelligence. Specifications used to evaluate 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, uses of computers, iteration and optimization in terms of design project. Co/Prerequisite: AM 121.

AM 342 Aircraft Design I 2:3:3

AM 343 Aircraft Design II 2:3:3
Structural designs of airplanes based on specification and aerodynamic requirements. Discussions of construction materials, forming, fasteners, fittings. Structural arrangement of landing gear, fuselage, stress analysis. Prerequisite: AM 342.

AM 344 Spacecraft Design 2:3:3
Designs of hypervelocity vehicles. Trajectory and orbit analyses, problems of re-entry, propulsion system design, 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 1:4:1
Instrumentation principles. Experiments related to thermodynamics, system modeling and basic instrumentation. Co/Prerequisites: AM 201 and AM 112.

AM 352 ME Laboratory II 1:4:1
Experiments related to thermodynamics, fluid properties, systems dynamics, vibrations. Co/Prerequisite: AM 261.

AM 353 ME Laboratory III 1:4:1
Experiments in heat transfer, fluid flow, stress and strain. Prerequisite: AM 203.

AM 361 ME Project Proposal 0:8:2
Basic design and analysis of engineering project. Formulation of formal plan of execution of design project. Prerequisite: senior status.

AM 362 ME Project 0:8:2
Execution of design project as proposed in AM 361. Prerequisite: AM 361.

AM 363-396 ME Project or Study 1-4 cr. as arranged
Continuation of AM 362 on approval of project adviser. Directed studies or special topics in mechanical engineering. Prerequisite: AM 362.
MECHANICAL AND AEROSPACE ENGINEERING

AM 381-382 Senior Honors Work in Mechanical Engineering I, II  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  credit to be arranged
For aerospace majors; equivalent in scope to AM 381-382.

AM 391-392 Guided Studies in Mechanical Engineering I, II  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  credit to be arranged
For aerospace majors; equivalent in scope to AM 391-392.

GRADUATE COURSES

AM 601 Stress Analysis I  2 ½:0:3

AM 602 Stress Analysis II  2 ½:0:3

AM 603-604 Elasticity I, II* each 2 ½:0:3

AM 605 Limit Analysis of Structures*  2 ½:0:3

AM 606 Applied Plasticity  2 ½:0:3

AM 607 Continuum Mechanics*  2 ½:0:3
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*  2 ½:0:3
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. Prerequisite: AM 121 or CE 202. Also listed under CE 621.

AM 613 Theory of Plates  2 ½:0:3
Bending theories of elastic plates of various shapes from equilibrium considerations. Equilibrium equations and boundary conditions derived from energy principles. Exact and approximate solutions (series, Rayleigh-Ritz, Galerkin). Introduction to large deflection and buckling theories. Application to structures and vehicles. Prerequisite: adviser's approval.

AM 614 Theory of Shells  2 ½:0:3
Membrane theory of arbitrary thin shells and linear bending theory of shells with emphasis on circular cylinders. Derivation of buckling theory of circular cylindrical shells. Applications include shell-type roof structures, pressure vessels, underwater structures, vehicles and aerospace structures. Prerequisite: AM 613.

AM 615 Energy Methods in Structural Analysis*  2 ½:0:3
Unified treatment of structural analysis using the principles of virtual work, total potential energy, total complementary potential, and mixed-energy. Applications to trusses, beams, frames, rings, sandwich structures, and to plane stress and plane strain problems. Rayleigh-Ritz procedure, Galerkin method. Prerequisite: adviser's approval.

AM 616 Theory of Elastic Stability*  2 ½:0:3
Energy methods employed to investigate buckling loads of structural configurations composed of beams, rings, plates, shells. Applications to problems of technical interest associated with structures and vehicles. Prerequisite: AM 615.

AM 621 Finite Element Analysis of Structural Systems*  2 ½:0:3

AM 623 Computational Methods in Mechanical and Aerospace Engineering*  2 ½:0:3
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 Fcullet, Ritz, Galerkin, least square and collocation methods.

AM 624 Computational Methods in Mechanical and Aerospace Engineering II  2 ½:0:3
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. Illustrative examples from contemporary literature in structural analysis. Prerequisite: AM 623.

AM 625 Experimental Stress Analysis*  1 2½:0:3
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.

AM 626 Advanced Topics in Experimental Stress Analysis*  1 2½:0:3
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 photoelasticity, moire analysis of three-dimensional surfaces by means of holography and other optical techniques. Prerequisite: AM 625.
AM 630 | Design Methods for Power Plant Structures | 2½-3

AM 632 | Introduction to Piping Analysis | 2½-3
Use of displacement energy, complementary energy and theore­
etical reformed 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 bimetals and layered elements. Prerequisite: AM 601.
Also listed under CE 632.

AM 634 | Pressure Vessel Analysis | 2½-3

AM 637 | Thermal Stress Analysis I* | 2½-3

AM 638 | Thermal Stress Analysis II* | 2½-3
Energy methods of thermal stress analysis, including modified Cas­
ligiano’s theorem, complementary energy, reciprocal theorem, 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 | 2½-3

AM 652 | Advanced Dynamics II | 2½-3
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, variational principles.

AM 653 | Dynamics of Machine | 2½-3
Dynamics of systems with one and two degrees of freedom. Energy methods, Rayleigh’s quotient. Generalized coordinates, Lagrange’s equations.

AM 654 | Mechanical Vibrations | 2½-3

AM 661 | Structural Dynamics | 2½-3

AM 662 | Vibration of Plates and Shells* | 2½-3

MECHANICAL AND AEROSPACE ENGINEERING

AM 683 | Matrix Methods in Vibrations* | 2½-3

AM 684 | Dynamic Stability of Structures* | 2½-3
Foundations of theory of dynamic stability. Dynamic stability of straight and curved beams, plates, and shells. Linear and nonlinear theories. Prerequisite: AM 615

AM 671 | Analysis of Machine* | 2½-3
Classification of mechanisms. Review of planar kinematic analysis. Algebraic and geometric methods for kinematic synthesis. Intro­duction to spatial linkages. Applications to mechanism design.

AM 682 | Aero- and Hydroelasticity* | 2½-3
Analysis of problems with nonconservative type forces. Divergence and flutter phenomena, flutter prevention. Applications to vibrations and instabilities in aerospace, mechanical and civil engineering. Prerequisite: AM 681.

AM 683 | Nonharmonic and Random Vibrations | 2½-3
Determination of factors controlling dynamic errors in shock and vibration; analysis of linear and nonlinear systems. Ritz averaging phase-plane and perturbation methods. Response to periodic and random excitation. Prerequisite: AM 684.

AM 685 | Analysis of Nonlinear Systems* | 2½-3

AM 685 | Noise and Acoustics I* | 2½-3
Survey of mathematical methods, random signals, acoustic fields, room acoustics, subjective criteria, environmental criteria.

AM 686 | Noise and Acoustics II* | 2½-3
MECHANICAL AND AEROSPACE ENGINEERING

AM 687 Acoustic Radiation from Submerged Structures* 2 5/0:3
Wave equation and elementary solution. Helmholtz integral formulation. Radiation from submerged plates and shells and associated sound radiators; scattering of sound by rigid and elastic scatterers; creeping waves.

AM 691-694 Special Topics: ME and Applied Mechanics* each 2 5/0:3
Topics of particular current interest in mechanical engineering and applied mechanics. Prerequisite: advisor’s approval.

AM 701 Thermodynamics IIS2 5/0:3
Available functions, general thermodynamic relations, equations of state, general thermodynamics equilibrium criteria. Prerequisite: AM advisor’s approval.

AM 702 Thermodynamics II* 2 5/0:3
Continuation of AM 701. Applications of thermodynamics equilibrium criteria to various problems, including chemical reactions. Prerequisite: AM 701.

AM 704 Aerothermochemistry 2 5/0:3
Fundamentals of chemical thermodynamics, fluid dynamics and chemical kinetics. Applications to combustion and emission phenomena, fluid lasers, plasmas and hypersonics. Prerequisite: AM 701.

AM 705 Combustion I 2 5/0:3
Chemical characteristics of flames. Heat of formation and of reaction; phase and reaction equilibrium 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 developed. Prerequisite: AM 701.

AM 708 Combustion II 2 5/0:3
Physical characteristics of flames. Basic equations of aerothermochemistry, flame propagation in initially mixed and premixed gases, laminar and turbulent flame speeds, combustion of liquid droplets and sprays, combustion of solid particles and flame spreading in solids, and chemical reactions in boundary layers. Prerequisite: AM 706.

AM 709 Special Topics: Thermodynamics and Combustion* 2 5/0:3
Topics of particular current interest in thermodynamics and combustion. Prerequisite: AM advisor’s approval.

AM 710 Convection 2 5/0:3
Developments and applications of laminar hydrodynamic and thermal boundary layer equations for fluid media. Mechanics of turbulence, formulation and analysis of turbulent hydrodynamics and thermal applications; natural convection and film evaporation and condensation. Prerequisite: AM 740 or equivalent.

AM 711 Convective Heat Transfer* 2 5/0:3
Theories of free and forced convective systems. Equations for heat transfer coefficients in compressible and incompressible fluids developed from boundary layer concepts. Applications to internal and external laminar and turbulent flows. Prerequisite: AM 710.

AM 712 Conductive Heat Transfer* 2 5/0:3
Theoretical development of transient and steady-state temperature distributions in finite and infinite solids. Appropriate mathematical techniques introduced as required. Solids undergoing phase change and two-dimensional fields. Prerequisite: AM 203.

AM 713 Radiative Heat Transfer* 2 5/0:3

AM 714 Radiation Gas Dynamics* 2 5/0:3
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 advisor’s approval.

AM 715 Heat Transfer 2 5/0:3
Basic heat transfer mechanisms. Steady and unsteady conduction, including systems with internal heat sources, internal and external forced and free convection. Radiation between surfaces and in gases. Dimensional and boundary layer considerations. Applications involving fins and heat exchangers. Credit for AM 715 will not be granted if AM 203 was taken. Prerequisite: AM advisor’s approval.

AM 716 Reactor Heat Transfer* 2 5/0:3
Heat transfer problems and solution techniques associated with nuclear reactors including BWR, PWR, LMFB, and HiGR. Representative core geometries and primary loop components. Flow boiling phenomena, liquid heat transfer, combined convection and radiation gas flow, LOCA and ECCS considerations. Prerequisite: AM 715 or AM 203.

AM 717 High-Performance Heat Exchangers* 2 5/0:3

AM 718 Multiphase Flows with Heat Transfer* 2 5/0:3

AM 729 Special Topics: Heat Transfer* 2 5/0:3
Topics of particular current interest in heat transfer. Prerequisite: AM advisor’s approval.

AM 731 Analytical Methods in Thermal and Fluid Mechanics* 2 5/0:3
Classifications of differential equations of fluid and thermal mechanics. Methods of characteristics for supersonic flow and wave propagation. Potential methods including complex variable applications for transforms techniques for convection and conduction. Prerequisite: AM advisor’s approval.

AM 732 Computational Methods in Thermal and Fluid Mechanics 2 5/0:3
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 advisor’s approval.

AM 740 Principles of Fluid Dynamics 2 5/0:3
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 advisor’s approval.

AM 741 Compressible Flow* 2 5/0:3
Subsonic, transonic and supersonics 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* 2½:0:3 Molecular and macroscopic transport, concepts of stress and strain, and derivation of the Navier-Stokes equations. Applications to problems of diffusion, boundary layers and slow motion. Analytic and numerical methods are presented. Prerequisite: AM 710.

AM 744 Viscous Compressible Flow* 2½:0:3 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. Prerequisite: AM 741 and AM 742.

AM 745 Hydrodynamics* 2½:0:3 General theorems of hydrodynamics. Analytical techniques including formulation of boundary conditions. Analyses of hydrofoils, planing, cavitation propellers and hydrofoils, flow about partially submerged bodies, wave drag, underwater propulsion, cascades, surface impact, geophysical problems. Prerequisite: AM adviser's approval.


AM 748 Dynamics of Rarefied Gases* 2½:0:3 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 Magnetofluid Dynamics* 2½:0:3 Dynamics of electrically conducted gases in electric and magnetic fields. Moving fields and electromagnetic equation: Maxwell stresses, field and momentum-energy tensors. Thermodynamics of fluids in electromagnetic fields. Magnetofluid dynamics, characteristics, waves, shock waves. Applications: MHD propulsion and power generation. Prerequisite: AM adviser's approval.

AM 750 Ocean Waves and Tides* 2½:0:3 Generation, propagation and decay of surface waves and well, 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* 2½:0:3 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. Flow and thermal characteristics over urban regions and various topographical configurations. Prerequisite: AM adviser's approval.

AM 752 Aerodynamics of Urban Environment II* 2½:0:3 Travel and dispersal of atmospheric pollutants. Plume rise 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 2½:0:3 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 instabilities treated as collision processes both classically and quantum theoretically. Determinations of self-consistent kinetic equations for both particles and waves. Applications to space-time evolution of coupled background and turbulent wave fields. Prerequisite: AM adviser's approval. Also listed under EL 781-782.

AM 755 Experimental Methods in Thermal and Fluid Mechanics* 2½:0:3 Measurement principles including mechanical, electrical, electromagnetic, thermal and optical techniques. Applications to measurements of forces, pressures, heat transfer, velocity and electron density. Schlieren, interferometry, laser, Raman scattering. Prerequisite: AM adviser's approval.

AM 759 Special Topics: Fluid Mechanics* 2½:0:3 Topics of particular current interest in fluid mechanics. Prerequisite: AM 740.

AM 761 Energy Conversion* 2½:0:3 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 2½:0:3 Basic course in the use of solar radiation for heating of buildings, swimming pools, domestic hot water, and other processes. Direct, diffused and ground-reflected solar radiation, sun angles, active and passive solar thermal engineering, building heat loss, 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 2½:0:3 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 cycles, solar assisted heat pump systems, absorption refrigeration cycles, heat engines, solar-driven air conditioners, solar dehumidifiers, concentrating solar collectors and use of reflectors to improve system performance. Prerequisite: AM 763.


AM 769 Special Topics: Energy Conversion* 2½:0:3 Topics of particular current interest in energy conversion. Prerequisite: AM adviser's approval.

AM 771 Computational Geometry for Computer-Aided Design 2½:0:3 Interactive computer graphics, with emphasis on design and manufacturing applications. 2D, 3D geometry and vector algebra. Transformation and viewing of 3D geometry. Parametric representation and design of 3D curve and surface geometry. Theory of splines. Overview of CAD packages. Prerequisite: AM adviser's approval.

AM 772 Computer-Aided Design 2½:0:3 Concepts and potentials of computer-aided design. Roles of interactive computer graphics in CAD. Hardware systems and existing software packages. Geometric modeling and object hierarchy. Raster: algorithms and display architecture. 3D modeling, hidden surface treatment, of CAD systems. Design programming, and uses of CAD systems. A project involving the development of CAD system is required. Prerequisite: AM 332 or AM 771.

AM 501 Trajectories and Orbits* 2½:0:3 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.
MECHANICAL AND AEROSPACE ENGINEERING

AM 802 Space Mechanics* 2½:0:3
Treatment of celestial mechanics including n-body problem, 3-body problem, restricted 3-body problem, Jacobi integral and applications, 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* 2½:0:3
Atmospheric flight mechanics of airplanes, quasi-steady and dynamic performance in various flight regimes, energy methods. Space vehicles, forcible motion in central force field, launch and re-entry trajectories. Land and seaborne vehicles: automobile, tracked vehicles, ship and GEM vehicles. Prerequisite: AM advisers approval.

AM 804 Vehicle Dynamics II* 2½:0:3

AM 808 Physics of the Atmosphere 2½:0:3

AM 810 Theory of Propulsion* 2½:0:3
Principles of modern propulsion based on chemical energy sources. Air-breathing engines, combustion thermodynamics, flows with chemical reactions, thermostability of solid and liquid rocket engines. Engineering parameters in engine design. Prerequisite: AM advisor's approval.

AM 811 Engine-Airplane Integration* 2½:0:3
Basic concepts underlying control of power plant and aerodynamic systems. Flow fields. Air inlet and exhaust region design requirements. Estimation of net axial forces. Use of thrust vectoring for attainment of VSTOL performance and for improved high-speed maneuvering capabilities. Prerequisite: AM advisor's approval.

AM 812 Helicopter Theory* 2½:0:3

AM 819 Special Topics: Aeronautics and Astronautics* 2½:0:3
Topics of particular current interest in aeronautics and astronautics. Prerequisite: AM advisor's approval.

AM 901-904 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 2½:0:3
See Energy Program for details (ES 927).

AM 928 Energy Resource Distribution and Conversion Technology 2½:0:3
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. Discussions from floor. Satisfactory attendance required of master's or engineer 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 ember. Project titles submitted in writing to department head and adviser appointed. May be extended to thesis with project adviser'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. Minimum 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 completion of project or related topics required of candidates. Continuous registration required until satisfactory project completed. Minimum of six, maximum of twelve units of AM 996-997 counted toward degree. Reregistration fee: 3-unit charge. Prerequisite: post-master status.

AM 999 Ph.D. Dissertation each 3 units
Doctor's dissertation evincing 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

Richard S. Thorson, Head of Mechanical & Aerospace Engineering and Dean of Research and Graduate Studies. B.Eng., City College of New York; M.Eng., Ph.D., New York University
Heat transfer, nuclear reactor safety, solar energy. CAD

Vito D. Agosta, Professor
B.S., Polytechnic Institute of Brooklyn; M.S., University of Michigan; Ph.D., Columbia University
Propulsion, heat power, heat transfer

Anthony E Armenakas, Professor
B.S., George Institute of Technology; M.S., Illinois Institute of Technology; Ph.D., Columbia University
Dynamic analysis of structures, fracture, wave propagation, numerical techniques

William Blesser, Professor
B.S., Rensselaer Polytechnic Institute; M.E.E., Polytechnic Institute of Brooklyn
Bioengineering, instrumentation, control systems, wave propagation, numerical techniques.
MECHANICAL AND AEROSPACE ENGINEERING

Sharad A. Patel, Professor
B.Sc., Benares Hindu University (India); M.Ae.E., Ph.D.,
Polytechnic Institute of Brooklyn
Solid mechanics, creep, structural analysis

Frank J. Romano, Professor and Administrative Officer,
Brooklyn
B.M.E., M.S., Ph.D., Polytechnic Institute of Brooklyn
Solid mechanics, structures, thermodynamics

Pasquale M. Storza, Professor
B.Ae.E., M.S., Ph.D., Polytechnic Institute of Brooklyn
Theoretical and experimental fluid dynamics, fluid power
engineering

Bernard W. Sheffer, Professor
B.M.E., CCNY, M.S., Case Institute of Technology; Ph.D.,
Brown University
Rational design, elasticity, plastic stress analysis

Simon Slutsky, Professor
B.C.E., CCNY; M.S., Columbia University; Ph.D.,
Polytechnic Institute of Brooklyn
Urban noise, engine noise, and vibrations

William P. Vafekos, Professor
B.M.E., M.M.E., Ph.D., Polytechnic Institute of Brooklyn;
J.D., Brooklyn Law School
Solid mechanics, structures

Philip Abrami, Associate Professor
B.M.E., M.S., Polytechnic Institute of Brooklyn
Mechanical analysis and design, sports product engineering

James Benton, Associate Professor
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn
Computational methods, hydrodynamics, areas engineering,
solar energy

Philip Chalkin, Associate Professor
B.M.E., City College of New York; B.M.E., New York
University
Graphics, computer programming

Robert Corry, Associate Professor
A.B., Columbia College; B.S., M.S., Ph.D., Columbia
University
Instrumentation

Jesse F. Crump, Associate Professor
B.S., M.D., University of Nebraska
Physiology, bioengineering, medical instrumentation

Morris P. Isom, Associate Professor
A.B., Harvard University; M.S., Massachusetts Institute of
Technology; Ph.D., Princeton University
Acoustics, gas dynamics, applied mathematics

August R. Krenkel, Associate Professor
B.S., M.S., Massachusetts Institute of Technology
Atmospheric flight dynamics, applied aerodynamics, aircraft
design

Jack E. Werner, Associate Professor
B.S., M.S., Massachusetts Institute of Technology; Ph.D.
Johns Hopkins University
Low-speed aerodynamics, shock waves, fluid mechanics

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., B.C.E., CCNY;
conservation
aerodynamics

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, and 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, and solar energy

Huo-Hsi Pan, Professor
B.S., National Southwest Associated University (China);
M.S., Texas A & M; M.S., Kansas State University; Ph.D.,
University of California (Berkley)
Solid mechanics, rational design, applied mathematics
MECHANICAL AND AEROSPACE ENGINEERING

Tsu-Chin Chu, Assistant Professor
B.S., Nat'l Cheng Kung University (Taiwan); M.S., Auburn University; Ph.D., University of South Carolina
Computer graphics, CAD/CAM, stress analysis

Chih-Shing Wei, Assistant Professor
B.S., Nat'l Chung Hsing University (Taiwan); M.S., State University of New York at Buffalo; Ph.D., Georgia Institute of Technology
Computer graphics, CAD/CAM, heat transfer

ADJUNCT FACULTY

Je Chul Kim, Adjunct Associate Professor
B.S., Massachusetts Institute of Technology; M.S., Northeastern University; Ph.D., Purdue University

Robert S. Levy, Adjunct Associate Professor
B.M.E., City College of New York; M.M.E., Ph.D., Polytechnic Institute of Brooklyn

Edward Pinnes, Adjunct Associate Professor
B.M.E., M.S., New York University; Ph.D., Polytechnic Institute of New York

Donald J. Render, Adjunct Associate Professor
B.S., University of Illinois; M.S., Massachusetts Institute of Technology; Ph.D., New York University

Arthur Rubel, Adjunct Associate Professor
B.M.E., City College of New York; M.M.E., Ph.D., New York University

Beauvais Fox, Adjunct Assistant Professor
B.S., Lehigh University

Bernard Roth, Adjunct Lecturer
B.M.E., M.S., City College of New York

John Sposito, Adjunct Lecturer
B.S.Ae.E., M.S., Polytechnic Institute of Brooklyn

Steven Vitale, Adjunct Lecturer
B.M.E., M.M.E., M.C.E., Polytechnic Institute of New York
METALLURGY AND MATERIALS SCIENCE

Metallurgists and material scientists are specialists in the most effective utilization of metals, alloys, ceramics, semiconductors, composites, plastics, and polymers. 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 three decades, we have witnessed increasing demands for ultrahigh-strength corrosion and heat resistant alloys, such as alloy steels, tungsten, titanium, beryllium, and molybdenum as well as nonmetallic epoxy-carbon composites. In electronics, we have witnessed tremendous growth in the use of silicon and other semiconductors for integrated circuits. Yet we have utilized only a fraction of the theoretical potentials of materials. Challenges remain for imaginative individuals to probe, understand, process, fabricate, and use effectively metallic materials, semiconductors, and composites in fields ranging from electronic devices and integrated circuits to new energy production processes and aerospace applications. The broad fields of metallurgy and materials science may be divided into several areas of specialization: physical metallurgy, materials science and engineering metallurgy.

Physical Metallurgy

Physical metallurgy is concerned with the study and understanding of fundamental properties of materials and how these properties are related to the macroscopic and microscopic behavior of metals and alloys. Chemical composition, processing variables, atomic bonding, crystal structure and microscopic imperfections are correlated with the strength, corrosion resistance, electrical properties, and physical and chemical characteristics 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 non-metallic materials such as ceramics and glasses, semiconductors, ionic solids, and even polymers.

Materials Science

It is estimated that nearly 40% of all engineering research is in the area of materials science, which is defined simply as the study of the interrelation among atomic structure, crystal structure, microstructure and properties of materials. With this understanding it is possible to "tailor make" materials requiring specific properties for particular applications. The fundamental principles which involve basic physics and chemistry are universally applied to metals, ceramics, polymers, and semiconductors. For thirty years, metallurgists have been using electron microscopy, vacuum technology, x-ray diffraction, and thermomechanical processing to influence and evaluate the structures of new alloys and semiconductors for structural and electronic device applications. It has been found that instrumentation and equipment necessary to study and develop processes for metallic materials are ideally suited to nonmetals. It has therefore been a natural evolution for metallurgically oriented academic programs to encompass the broader spectrum of electronic materials, ceramics, and composites.

Engineering Metallurgy

In engineering metallurgy, engineering application of metallic materials directly reflect on the electronic, aerospace, energy and chemical production and transportation industries. Metallurgical engineers play vital roles in materials selection and process optimization. They have thorough knowledge of existing metallic materials, their properties and limitations. Borrowing fundamental knowledge from physical metallurgy, they constantly search for new and better materials to improve processes and products. Some areas in which metallurgical engineers work are: prevention of corrosion and environmental degradation; welding alloys and composites; failure analysis; product reliability and safety; quality control; materials characterization; and alloy development. Furthermore, metallurgists may work in research and development; plant operations or consulting. Metallurgists contribute to progress in oceanography, medical prosthetics, dental materials, environmental protection and electronic devices.

PROGRAMS OF STUDY

- Bachelor of Science in Metallurgical Engineering with concentration in Materials Science
- Master of Science
  - Metallurgical Engineering
  - Materials Science
  - Manufacturing Engineering of Electronic Materials
- Ph.D.
  - Metallurgical Engineering
  - Materials Science

Undergraduate programs are approved 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 aims, providing the capability to solve present problems and the ability to keep pace with technological advancements and increasingly complex problems of the future.

Specifically, the curriculum consists of 39 credits in mathematics, physics and chemistry, 24 credits in the humanities and social sciences, 53 credits in engineering.
METALLURGY AND MATERIALS SCIENCE

science, materials sciences, engineering design and systems, 9 credits of technical electives, 3 credits of free electives and 8 credits of thesis.

During their junior and senior years metallurgy students may broaden their programs by concentrating the technical elective sequence of 12 credits in several areas: material science, computer science, industrial engineering, mathematics or the sciences as approved by advisors.

Students may (with advisers’ 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 the section Degree Requirements.

Freshman and sophomore years of metallurgical engineering curricula may be taken on the Long Island Campus. Junior and senior metallurgy courses are offered only on the Brooklyn campus. Any non-metallurgy courses listed in the last two years may also be taken at the Long Island campus, provided they are offered.

GRADUATE STUDIES

The Department of Metallurgy and Materials Science prepares students for the degree of master of science in materials science and metallurgical engineering, the degree of Engineer in metallurgical engineering, and the degree of Doctor of Philosophy in materials science. The courses of study and research leading to these degrees are designed for students holding baccalaureate degrees in metallurgy or materials science. Students holding baccalaureate degrees in related disciplines are admitted, if undergraduate deficiencies are removed.

Both fundamental and applied research are carried on with the department. Excellent facilities are available for work in electron microscopy, x-ray diffraction, deformation and fracture and other fields. Fundamental research is carried out on alloy hardening, deformation and fracture, phase transformations, thermomechanical working, ternary diffusion and rapid solidification. In applied research, the Department is involved in studies of materials for aerospace, electronic applications and energy related applications. The rules governing admittance to graduate studies are applicable to all students.

*Subject to registration by N.Y.S. Education Department.
Typical Course of Study for the Bachelor of Science Degree in Metallurgical Engineering

**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>
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<td>No. Subject</td>
<td>Cl. Lab. Cr.</td>
</tr>
<tr>
<td>CM 101</td>
<td>2 1/2 0 2 1/2</td>
<td>CM 102</td>
<td>2 1/2 0 2 1/2</td>
</tr>
<tr>
<td>CM 111</td>
<td>0 1 1/2 1/2</td>
<td>CM 112</td>
<td>0 1 1/2 1/2</td>
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<td>HU 101</td>
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<td>HU 200</td>
<td>3 0 3</td>
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<td>SS 104</td>
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<td>MA 102</td>
<td>4 0 4</td>
</tr>
<tr>
<td>MA 101</td>
<td>4 0 4</td>
<td>PH 102 Intro. Physics II</td>
<td>3 1/2 1 1/2 4</td>
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<tr>
<td>PH 101 Intro. Physics I</td>
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<tr>
<td>PE 101 Physical Education</td>
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**Sophomore Year**

<table>
<thead>
<tr>
<th>No. Subject</th>
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<th>No. Subject</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>AM 115 Eng. Mechanics</td>
<td>4 0 4</td>
<td>EE 370 Princ. Elec. Eng.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>AM 101 Graphics</td>
<td>1 3 2</td>
<td>EE 374 Inst. Lab.</td>
<td>0 3 1</td>
</tr>
<tr>
<td>PH 103 Intro. to Physics III</td>
<td>2 1/2 1 1/2 3</td>
<td>AM 121 Mech. of Materials</td>
<td>3 0 3</td>
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<tr>
<td>MA 103 Calculus III</td>
<td>3 0 3</td>
<td>MA 104 Appl. Diff. Eqs.</td>
<td>3 0 3</td>
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<tr>
<td>PE 103 Physical Education</td>
<td>0 2 0</td>
<td>PE 104 Physical Education</td>
<td>0 2 0</td>
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<tr>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 6</td>
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**Junior Year**

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<thead>
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<th>No. Subject</th>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>MT 401</td>
<td>3 0 3</td>
<td>CM 161 Physical Chemistry I</td>
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<tr>
<td>MT 402</td>
<td>3 3 4</td>
<td>MT 403 Physical Metallurgy II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MT 404</td>
<td>0 6 2</td>
<td>MT 405 Mechanical Metallurgy II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MT 405</td>
<td>3 0 3</td>
<td>MT 407 Metallurgy Transport</td>
<td>3 0 3</td>
</tr>
<tr>
<td>Metallurgical Thermodynamics</td>
<td>3 0 3</td>
<td>MT 408 Phys. Metallurgy Lab.</td>
<td>0 6 2</td>
</tr>
<tr>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
<td>MT 494 Literature Search</td>
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<tr>
<td>Elective*</td>
<td>3 0 3</td>
<td>Elective*</td>
<td>3 0 3</td>
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**Senior Year**

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<th>No. Subject</th>
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<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 410</td>
<td>3 0 3</td>
<td>CM 771 Intro. to Polymer Chemistry</td>
<td>3 0 3</td>
</tr>
<tr>
<td>CM 515</td>
<td>2 1/2 0 3</td>
<td>MT 413 Process Metallurgy</td>
<td>3 0 3</td>
</tr>
<tr>
<td>Elective*</td>
<td>3 0 3</td>
<td>MT 423 Ceramic &amp; Refract. Mat.</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MT 416</td>
<td>2 3 3</td>
<td>MT 497 Thesis</td>
<td>0 9 3</td>
</tr>
<tr>
<td>MT 421 Metal. Failure Analysis</td>
<td>2 3 3</td>
<td>Hum./Soc. Sci. elective</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MT 496</td>
<td>0 9 3</td>
<td>Elective*</td>
<td>3 0 3</td>
</tr>
<tr>
<td>Elective*</td>
<td>3 0 3</td>
<td></td>
<td>18</td>
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</tbody>
</table>

Total credits required for graduation: 136
### REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

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 Advisory Committee.

Full-time graduate students enrolled in the master's program will generally be required to do a master's thesis. Part-time students will be required to complete a master's project. Under special circumstances students may take courses and pass an oral examination in lieu of a thesis or project.

A minimum of 36 units of required and elective courses, and thesis or project is necessary for the M.S. degree.

### M.S. Metallurgical Engineering

**Required Course Work:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MT 600 Structure-Property Relationships</td>
<td>3</td>
</tr>
<tr>
<td>MT 610 Thermodynamics of Metals &amp; Alloys</td>
<td>3</td>
</tr>
<tr>
<td>MT 620 Plastic Deformation &amp; Fractures</td>
<td>3</td>
</tr>
<tr>
<td>MT 630 Theory of Metals</td>
<td>3</td>
</tr>
<tr>
<td>MT 640 Reactions in Solids</td>
<td>3</td>
</tr>
<tr>
<td>MT 650 Advanced Engineering Metallurgy</td>
<td>3</td>
</tr>
</tbody>
</table>

**Project or Thesis**

* MT 968 Project for M.S. 3-6
  * MT 997 Thesis for M.S. 6-12

### Elective Course Work:

12-18 units chosen from the Department courses listed on pages XX of the Catalog.

### General Electives

With adviser's approval may be chosen from among University courses offered in this catalog.

Total 36

### M.S. Materials Science

Enrollment in the program is open to students with undergraduate degrees in engineering or the physical sciences. Depending on the undergraduate background, two 500 level courses may be required to satisfy principal prerequisite requirements:

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>CM 515 Polymer Organic Chemistry</td>
<td>3</td>
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<tr>
<td>MT 540 Survey of Metallurgical Principles</td>
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</tr>
</tbody>
</table>

(These courses may not carry credit towards degrees).

**Required Course Work (15 units)**

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>MT 600 Structure Property Relationships</td>
<td>3</td>
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<tr>
<td>MT 640 Reactions in Solids</td>
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<tr>
<td>MT 660 Ceramic Technology</td>
<td>3</td>
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<tr>
<td>CM 771 Introductory Polymeric Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CH 917 Introduction to Polymeric Materials</td>
<td>3</td>
</tr>
</tbody>
</table>

**Project or Thesis**

* MT 996 Report Project for M.S. 3-6
  * MT 997 Thesis for M.S. 6-12
Elective Course Work:
With Advisor approval courses from catalog,
others in areas related to materials science,
e.g., metallurgy, chemistry and polymers.

| No. | Required Subjects                      | Units |
|-----|-------------------------------- -------|------|
| MT 621-622 | Special Topics in Plastic Deformations & Fractures | 6    |
| MT 651-652 | Special Topics in Advanced Engineering Metallurgy | 6    |
| MT 762 | Seminar - presented by students critically reviewing technical papers selected by students with approval of faculty advisers. | 18   |
| MT 998 | project                                | 6    |
|       |                                           | 36   |

REQUIREMENTS FOR THE ENGINEER DEGREE

Applicants for admission to this program must hold master’s degrees (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 master’s degrees. 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 department graduate advisor, are removed during the time students are enrolled in the program.

| No. | Required Subjects                      | Units |
|-----|-------------------------------- -------|------|
| MT 402 | Mechanical Metallurgy I                | 3:0:4|
| 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|
| MT 408 | Physical Metallurgy Laboratory         | 0:6:2|
| 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|

REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY

Requirements for Doctor's degree conform to regulations in Degree Requirements. Specific doctoral requirements are available from the Departmental Secretary in the publication, Guide for Doctoral Students in Metallurgy or Materials Science.

A typical program consists of a minimum of 66 units of course work beyond the B.S. level and 24 units of research for the doctoral dissertation. Courses include major concentrations in Metallurgy/Materials Science of 36 units and minor areas of 12 units in related areas of physics, chemistry, etc.

UNDERGRADUATE COURSES

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<th>No.</th>
<th>Required Subjects</th>
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<tr>
<td>MT 401</td>
<td>Physical Metallurgy I</td>
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<td>MT 402</td>
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<td>MT 403</td>
<td>Physical Metallurgy II</td>
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<td>MT 404</td>
<td>Metallography Laboratory</td>
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<td>MT 405</td>
<td>Metallurgical Thermodynamics</td>
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METALLURGY AND MATERIALS SCIENCE

MT 401 Physical Metallurgy I 3:0:3

MT 402 Mechanical Metallurgy I 3:0:4

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
Production and properties of x-rays. Elements of crystallography. Stereographic projection. Powder and single crystal diffraction techniques. Structures and crystal orientation. Stress analyses and phase diagram determinations by x-ray techniques. Qualitative and quantitative chemical analyses by x-ray techniques. Prerequisites: MA 104 and PH 103. Also listed under PH 372.

MT 413 Process Metallurgy 3:0:3
METALLURGY AND MATERIALS SCIENCE

MT 416 Electrometallurgy and Corrosion 2:3:3

MT 421 Metallurgical Failure Analysis 1:6:3
Metallurgical principles applied to analyses of in-service failures of materials. Discussions 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 408.

MT 423 Introduction to Ceramic Refractory Materials 3:0:3

MT 484 Informational Search 1:3:2
Preparation and presentation by students of papers in metallurgical engineering, physical metallurgy or material science literature. Topics may be related to bachelor’s theses.

MT 488-487 Bachelor’s Thesis in Metallurgical Engineering each 3 credits
Carefully planned original investigations on topics approved by head of department. Results must show conclusive evidence of students’ abilities to attack and solve problems pertaining to metallurgy. Regular conferences and written reports required during progress of work; examinations given mid-thesis and when theses are completed. Prerequisite: MT 494.

TECHNICAL ELECTIVE COURSES

MT 409 Materials Selections 3:0:3
Knowledge of metallurgy and materials science applied to engineering materials selections. Value engineering approach and organization for materials selections. Elementary statistics applied to specifications, quality standards, quality controls. Prerequisite: MT 403.

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. Theories and applications of arc, gas, resistance and solid state welding processes. Modern methods of procedure, control, testing, inspection. Examinations of micro- and macro-structures of welds and adjacent areas. Applications of welding. Weldability criteria. Prerequisite: MT 402 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

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 investigations 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. Also listed under CE 303.

MT 304 Materials Science 2:3:3
Plastic behavior of single and polycrystalline materials. Deformation mechanisms. Effects of temperature and deformation on rate of plastic flow. Strain hardening. Dislocation theories. 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 processes, hot and cold, mechanics of deformation. Unconventional processing: EDM and ECM. Numerical control metrology. Prerequisite: MT 301 or MT 401. Also listed under IE 340.

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. Prerequisite: EE 111. 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 materials arranged by faculty steering committee.

MT 420 Engineering Materials 3:0:3
Structures, properties and uses of polymers and metals as engineering materials. Crystal structures, defects, heat treatments, corrosion and its prevention. Manufacturing and processing of polymers. Mechanical behavior of polymers and their thermal and electrical properties. Prerequisites: CM 161, CM 162, CM 123 and MC 124. Also listed under CH 271.
GRADUATE COURSES

MT 540 Survey of Metallurgical Principles 2 1/2:0:3
Crystal structures, alloying, phase diagrams, diffusion phenomena, mechanical deformations of metals and alloys, recrystallizations, age hardening. Prerequisite: instructor’s consent.

MT 600 Structure-Property Relationships in Materials 2 1/2:0:3
Dependences of properties, e.g., mechanical and electrical, on structures of materials. Crystalline vs. amorphous structure, occurrences and roles of defects. Bondings and structures. 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 1/2:0:3
Advanced or specialized topics in structure-property relationships materials presented at irregular intervals. Prerequisite: MT 600.

MT 603 Introduction to Electron Microscopy I 2 1/2:0:3

MT 604 Introduction to Electron Microscopy II 2:2:3

MT 610 Thermodynamics of Metals and Alloys 2 1/2:0:3
Fundamentals of classical and statistical thermodynamics with emphasis on solid states, phenomenology of metallic surfaces, phase equilibria in multicomponent 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 1/2:0:3
Advanced or specialized topics in thermodynamics and statistical mechanics of metals. Prerequisite: MT 610.

MT 620 Plastic Deformation and Fracture 2 1/2:0:3

MT 621-622 Special Topics in Deformation and Fracture I, II* each 2 1/2:0:3
Advanced or specialized topics in deformation and fracture. Prerequisite: MT 620.

MT 630 Theories of Metals 2 1/2:0:3
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, influences of structural imperfections on properties of metals and alloys. Prerequisite: MT 410 or equivalent.

MT 631-632 Special Topics in Theory of Metals I, II* each 2 1/2:0:3
Advanced or specialized topics in theories of metals. Prerequisite: MT 630.

MT 640 Reactions in Solids 2 1/2:0:3
Mechanisms and kinetics of diffusion-controlled and diffusionless phase transformations in solid metallic systems; diffusions in multiphase, multicomponent metallic systems; theories of precipitation, of grain boundary migration and grain growth, of eutectoid transformations and of martensitic transformation. Prerequisite: MT 414.

MT 641-642 Special Topics in Reactions in Solids I, II* each 1 1/2:0:3
Advanced or specialized topics in reactions in solids. Prerequisite: MT 640 or instructor’s consent.

MT 650 Advanced Engineering Metallurgy 2 1/2:0:3
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 designs and designs of alloys for challenging environments. Prerequisite: MT 405.

MT 651-652 Special topics in Advanced Engineering Metallurgy I, II* each 2 1/2:0:3
Advanced or specialized topics in advanced engineering metallurgy presented at regular intervals. Prerequisite: MT 650.

MT 660 Ceramic Technology 2 1/2:0:3
Chemistry, structures, and properties of ceramics and glasses. Emphasis on relation of microstructures to properties and control of microstructure via time-temperature as well as chemistry. Key engineering properties: strength, thermal resistance, dielectric behavior will be analyzed.

MT 700 Welding Metallurgy 2 1/2:0:3
Analyses of process variables affecting joining techniques. Studies of arc characteristics, heat flow, gas-metal interactions, solidification mechanisms, residual stress effects, distortion controls, Applications of solid-phase bonding, electron and laser welding Weldability criteria for ferrous and nonferrous alloys. Prerequisite: instructor's consent.

MT 705 Magnetism and Magnetic Materials* 2 1/2:0:3

MT 706 Thin Film Technology 2 1/2:0:3
Preparation, structure, evaluation and properties of thin films: metallic, semi-conductor 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
Nature of semiconductor materials, stressing interrelations among band structure, chemistry and microstructure of materials. Elemental, compound, amorphous and polymeric semiconductors. Examples of applications of materials for devices are given to illustrate how materials properties are matched to device characteristics for optimum performance.
METALLURGY AND MATERIALS SCIENCE

MT 709 Integrated Circuit (VLSI) Fabrication Techniques 3:0:3
Study of process technology used to produce integrated circuits. Silicon technology: bipolar, MOS, and VLSI processes. Process requirements defined in terms of circuit structure, i.e., concentration profiles and topographical layout as defined by mask set previously determined. Steps from crystal growth through diffusion, ion implantation, oxidation, photolithography, metallization, interconnections, and packaging to final test are analyzed. The impact of process on design rules are pointed out.
Also listed under EL 846.

MT 710 Powder Metallurgy 2½:0:3
Theoretical and practical aspects of powder metallurgy. Production of metal parts from powder, review of commercial applications. Theories of metal synthesis, compacting, consolidation and sintering. Important patents and commercial processes discussed. Prerequisite: Instructor's consent.

MT 714 Electrochemical Processes 2½:0:3

MT 715 Corrosion and Oxidation Mechanisms in Metals 2½:0:3
Electrochemical principles applied to corrosion. Analysis of corrosion mechanisms. Studies of preventive methods. Effects of temperature, environmental and metallurgical factors. High-temperature oxidations and gas-metal interactions. Testings. analyses of use of cathodic protection, water treatment, cathodic and anodic coatings. Prerequisite: MT 405 or instructor's consent.

MT 720 Advances in Materials Analyests and Characterizations 2½:0:3
Characterizations of microstructure, defects, dopants and impurities, composition profiles. What to use when and why. Hands on uses of selected equipment. Applications discussed based on interest of students.

MT 725 Noble Metal Metallurgy 2½:0:3
Crystal structures 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 mobile metal alloys. Prerequisite: instructor's consent.

MT 726 Metallurgy of Nuclear Reactor Materials 2½:0:3
Material requirements for basic parts of nuclear reactors. Metallurgy of fuels, moderator, control and construction materials. Descriptions of handling and fabricating techniques. Prerequisite: Instructor's consent.
Also listed under NU 718.

MT 727 Bioengineering Metallurgy 2½:0:3
Selection and application of alloys and alloys for uses in body environment, he body as corrosive environment. Examinations of major problem areas. Principles and techniques for preparation of dental amalgams and other alloys. Designs of alloys for bioengineering applications. Prerequisite: instructor's consent.
Also listed under BE 741.

MT 760-781 Seminar in Metallurgical Engineering each 0:2½:1½
Recent progress in metallurgical engineering in lectures by engineers from industry, research and educational institutions. One or more seminar topics from current literature in metallurgical fields assigned each student for presentation. Students expected to read each assigned topic to be conversant with topics presented. (Attendance required for two semesters. Part-time students may substitute a three-unit metallurgy course.)

MT 782 Seminar in Metallurgical Engineering 0:2½:0
Preparation and presentation by students of seminars on topics of metallurgical engineering, in which students critically review technical papers selected by students with approval of faculty advisers. For students enrolled in metallurgical engineering degree programs.

MT 783-786 Seminar in Metallurgy and Materials Science each 0:2½:0
Preparation and presentation by students of seminars on topics of physical metallurgy, metallurgical engineering, or materials science in which students critically review technical papers selected by students with approval of faculty advisers. For students enrolled in doctoral programs.

MT 927 Energy Policy Issues 2½:0:3
See Energy Program for details.

MT 928 Energy Resource Distribution and Conversion Technology 2½:0:3
See Energy Program for details.

MT 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.

MT 998 Report Project for the Degree of Master of Science 3-6 units
Independent project demonstrating professional maturity and graduate-level knowledge. Completed under guidance of departmental advisers. Reports include critical analysis and interpretation of pertinent literature and should represent worthwhile contributions to the field. Oral final examinations and project reports required.

MT 997 Thesis for the Degree of Master of Science 3-12 units
Extension of project studies to thesis level with approval of division head. Regular conferences and reports during thesis investigation required.

MT 998 Project for the Engineer Degree 3-6 units
Engineering project subject to the level of guidance of faculty members. Candidates required to take oral examination on subject matter of project and on related topics.

MT 999 Dissertation for the Degree of Doctor of Philosophy 3-6 units
Dissertation presents results of original research in physical metallurgy. Work must demonstrate originality and creativity and be worthy of publication in recognized scientific journals. Candidates must take oral examination on thesis subject and related topics. Minimum of 35 units required.

FACULTY

George Fischer, Professor of Metallurgy and Head of Metallurgy and Materials Science
B.M.E., M.Met.E., Polytechnic Institute of Brooklyn
Corrosion and welding metallurgy

Irving Cadoff, Professor of Materials Science
Electronic materials; liquid metal embrittlement; thin film epitaxy

Louis Castelma, 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

Sung Whang, Associate Professor of Metallurgy
B.S., Seoul National University (Korea); M.S., D.Eng.Sc.,
Columbia University
Physical metallurgy, materials science and metallurgical engineering

Said Nourbakhsh, Assistant Professor of Metallurgy
B.S., Arya-Mehr University of Technology (Iran), Ph.D.,
Leeds University (England)
Phase transformation, electron microscopy and mechanical behavior

ADJUNCT FACULTY

Simon Strauss, Distinguished Visiting Professor of Metallurgy and Fellow of the Polytechnic

Paul Cascone, Adjunct Professor of Metallurgy
B.E., New York University; M.S., Rutgers University

Davendra Gupta, Adjunct Professor of Metallurgy
B.Sc., Delhi University (India); B.Sc., Banaras Hindu University (India); M.S., N.Y.U.; Ph.D., University of Illinois

Henry Hausner, Adjunct Professor of Metallurgy
E.E., Dr.Eng., Technical University (Vienna, Austria)

Ernest Levine, Adjunct Professor of Metallurgy
B.Met.E., Rensselaer Polytechnic; Ph.D., N.Y.U.

James Lloyd, Adjunct Professor of Metallurgy
B.S., M.S., Ph.D., Stevens Institute of Technology

Robert Rosenberg, Adjunct Professor of Metallurgy
B.S., Drexel University; M.S., Ph.D., N.Y.U.

Sankar Sastri, Adjunct Professor of Metallurgy
B.S., Indian Institute of Science (India); M.S., Columbia University; Ph.D., Polytechnic Institute of New York

George Stern, Adjunct Professor of Metallurgy
B.Ch.E., C.C.N.Y.; M.S., University of Michigan

Anthony Vecchio, Adjunct Professor of Metallurgy
M.Met.E., Polytechnic Institute of Brooklyn

John Weeks, Adjunct Professor of Metallurgy
B.S., Colorado School of Mines; M.S., Ph.D., University of Utah

EMERITUS FACULTY

John Nielsen, Professor Emeritus of Metallurgy
M.E., Ph.D., Yale University
Precious metals and alloys, grain growth and recrystallizations, dental materials
MILITARY SCIENCE

The department of military science administers the Reserve Officer Training Corps program and provides college-trained officers for the United States Army, the National Guard and the United States Army Reserve. Best explained in the words of Dr. Lee S. Dreyfus: "The Reserve Officers Training Corps is not the presence of the military in the university, but rather the presence of the university in the military".

Through the department of military science the United States Army gains officers with excellent educational backgrounds and contemporary ideas. Military science graduates have the chance to use their ideas in positions of leadership and enable the Army to remain aligned with our ever-changing society.

Military science enhances a student's education by providing unique leadership and management experience found in 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 United States Army while earning their college degrees.

OFFICER EDUCATION PROGRAM

THE FOUR-YEAR PROGRAM

The four-year military science 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, basic rifle 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. Students who participate in the basic course are excused from physical education requirements.

All students in the basic course are organized into the cadet student brigade. Some Saturday or weekend training is included in the coursework. Uniforms may be issued to basic course students who are active in military science program, but uniform wear is not mandatory.

Advanced Course—The advanced course is 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 the 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 and field environment.

All cadets in the advanced course receive uniforms, necessary military science textbooks and pay for advanced camp ($600). Contracted 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, but they do 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 a 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 the basic course and have two years remaining in school. Students can take advantage of this opportunity by successfully completing a paid, six-week basic camp offered at Fort Knox, Kentucky, each summer and enrolling in the advanced course in their last two years, provided they otherwise meet enrollment requirements.

OBLIGATIONS

Upon commissioning, students may fulfill their contract obligations by either serving on active duty or by becoming a member of a local United States Army Reserve or National Guard unit.

Based upon the current manning requirements of the full time active duty forces, only one third of each commissioning year group is selected for active duty. Therefore competition for these slots is intense. For students interested in remaining in the local area and pursuing a civilian career, Reserve forces duty is usually preferred. This consists of one weekend drill per month and a two week period of active duty each summer. Qualified students may be guaranteed reserve forces duty prior to committing themselves to the advanced course by electing to sign a guaranteed reserve forces duty contract.

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.

MILITARY SCIENCE SCHOLARSHIPS

The department of military science 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 military science.

Students who attend the basic camp of the two-year program may also compete for two-year scholarships.

All scholarships pay for tuition, a stipend for 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 mandatory Polytechnic physical education requirements for graduation.

The number of military science credits which are applicable toward Polytechnic degrees depends upon the student's academic major and upon which courses the student chooses to replace with MS 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

Military science 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 to Polytechnic. An annual military ball is sponsored by the local chapter.

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 ceremonial color guard.

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 (Sappers) 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 desired 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 military science, telephone (718) 643-2105.

BASIC COURSES

MS 101 Introduction to military science I 1:1:0
History and organization of the Reserve Officer Training Corps; organization and purpose of the United States defense establishment; the roles of key government organizations and officials in defense matters; an introduction to physical fitness training and planning; and basic rifle marksmanship. The course also includes a field trip which applies all skills taught. Extra credit field training exercises are available.

MS 102 Introduction to military science II
Development of self-confidence in students. Development of skills necessary to navigate using a map and compass. (A field trip is required which applies all military skills taught.) First aid measures consisting of basic life-saving steps. Extra credit field training exercises are available. Prerequisite: MS 101 or permission of instructor.

MS 201 Military Skills I 1:1:1
Basic skills associated with small unit leaders. Theoretical and practical applications of military marksmanship, tactics and communications skills. Basic marksmanship includes the supervised firing of small bore rifle and pistol during an off campus field trip. Tactics is taught at the small unit level, company and below. Oral and written communications techniques and skills required of successful leaders. Students are required to participate in practical exercises which apply all military skills from previous classes. Extra credit field training exercises are available. Prerequisite: MS 101 and 102 or permission of instructor.

MS 202 Military Skills II 1:1:0
This course is a continuation of MS 201. A large portion is devoted to the study of leadership on an individual level. Principles and traits of leadership, human behavior and psychology, command, discipline, decision making and the leadership assessment program. How to prepare to conduct performance oriented training. The course also includes a field trip which applies all military skills previously taught. 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 as arranged
Theory and techniques used by successful leaders and managers. Management skills of problem analysis, decision making, planning, organizing, delegation and control are developed and applied within contexts of realistic situations, using individual and small group practical exercises. Interpersonal skills needed to utilize skills in relations with others are developed and practiced.
**MILITARY SCIENCE**

**MS 302  Leadership Skills I**  
3:0:0  
Soldier skills, physical capabilities and high motivational attitudes required to meet demands of today's modern army officers. Cadets receive hands-on training on military equipment and practical work experience emphasizing their roles as group leaders. Students work as a team, building individual confidence as well as team rel­a­lance. Leadership camp 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  
Interrelationship between the American military establishment and American society: development of the American military system; study of American wars; their causes, conduct and results; study of selected campaigns and battles; role of technology in evolution of tactics and strategy.

**MS 304  Leadership Skills II**  
3:0:0  
This course is a continuation of MS 302. Students are required to attend various field training exercises to reinforce classroom training, plus a five-day training session conducted just before advanced camp. Prerequisite: MS 302 and permission of the department head.

**Advanced Summer Camp**  
nc  
All candidates for commission through military science are required to successfully complete 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  
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. Ethical reasoning and decision-making processes developed and utilized in relation to case studies.

**MS 403  Pre-Commissioning Seminar**  
2:1:2 or nc as arranged  
Preparation of 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**

- **CPT John W. Tarver,** Assistant Professor of Military Science  
  B.A. Hardin-Baylor

- **CPT Ralph S. Zellem,** Assistant Professor of Military Science  
  B.S., St. John's University; M.B.A., Central Michigan University

- **CPT Dale A. Fye,** Assistant Professor of Military Science  
  B.S. U.S. Military Academy

- **SGM Morgan Highsmith,** Detachment SGM, Chief NCO Instructor

- **MSG William B. Tate,** Operations NCO, Instructor

- **SSG David M. Lange,** Administrative NCO, Instructor

- **SSG Arturo Sandoval,** Supply NCO, Instructor
OPERATIONS MANAGEMENT

Operations management addresses specific manufacturing and service operations to maximize the cost leverage of the organization. There is a growing perception that productivity is the key to successful world market competition and that not enough managers have the pertinent skills. Today's operations managers require skills reaching beyond those based only on industrial engineering; they must understand accounting, psychology, various productivity measurement techniques and management information system.

The roles of operations managers reach beyond production, being integrated into corporate management rather than isolated in factories. In addition to purely manufacturing settings, production and operations management techniques are used in health care organizations, financial institutions, insurance companies, transportation operations, distribution outlets, hotels, etc. Students select this program to take advantage of the current opportunities for jobs in operations management without having to choose between MBA or industrial engineering degrees.

Courses in operations management cover viewpoints and skills drawn from the fields of management and industrial engineering, including statistics, computers, work design and measurement, organization design, accounting, productivity management, statistical quality control, and organizational psychology.

This multidisciplinary graduate program is administered by the Division of Management and prepares students to manage technological, social and economic developments which affect the means and methods of satisfying needs for products and services.

REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

To be eligible for admission into this program, applicants must hold a baccalaureate 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 adequate preparation in mathematics. Those lacking such backgrounds may be admitted but are asked to take courses to make up deficiencies. Knowledge of computer programming also is assumed, or can be satisfied by taking IE 501 or MG 502. Effective writing skills are also assumed, or can be satisfied by taking HU 605. Such courses are in addition to other normal degree requirements.

A. Basic required courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 551</td>
<td>Applied Statistics I (Data Analysis)</td>
<td>12</td>
</tr>
<tr>
<td>IE 600</td>
<td>Engineering Economy Analysis</td>
<td></td>
</tr>
<tr>
<td>IE 606</td>
<td>Work Design and Measurement</td>
<td></td>
</tr>
<tr>
<td>MG 504</td>
<td>Managerial Accounting</td>
<td></td>
</tr>
<tr>
<td>MG 600</td>
<td>Management Process</td>
<td></td>
</tr>
</tbody>
</table>

B. Required 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>15</td>
</tr>
<tr>
<td>MG 630**</td>
<td>Operations Management</td>
<td></td>
</tr>
<tr>
<td>MG 810</td>
<td>Project Planning and Control</td>
<td></td>
</tr>
<tr>
<td>MG 645</td>
<td>Productivity Management</td>
<td></td>
</tr>
<tr>
<td>IE 611</td>
<td>Statistical Quality Control</td>
<td></td>
</tr>
</tbody>
</table>

C. Major electives (Choose Three)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG 608</td>
<td>Managerial Economics</td>
<td>9</td>
</tr>
<tr>
<td>IE 776</td>
<td>Manufacturing Resource Planning</td>
<td></td>
</tr>
<tr>
<td>IE 777</td>
<td>Manufacturing Improvement Curves</td>
<td></td>
</tr>
<tr>
<td>MG 607</td>
<td>Marketing Management</td>
<td></td>
</tr>
<tr>
<td>MG 850</td>
<td>Cost Systems</td>
<td></td>
</tr>
<tr>
<td>IE 765</td>
<td>Human Factors in Engineering Design</td>
<td></td>
</tr>
<tr>
<td>IE 775</td>
<td>Industrial Safety Engineering</td>
<td></td>
</tr>
<tr>
<td>SS 920</td>
<td>Proseminar in Psychology</td>
<td></td>
</tr>
<tr>
<td>SS 926</td>
<td>Environmental Psychology</td>
<td></td>
</tr>
<tr>
<td>MG 624</td>
<td>Organization Development</td>
<td></td>
</tr>
</tbody>
</table>

Total: 36

---

*All group A courses are required unless they are specifically waived by advisers because students either (a) have taken equivalent undergraduate or graduate courses, or (b) pass validation examinations for these courses. Up to four group A courses actually taken may be credited toward degree requirements; if more than four must be taken, degree requirements are increased accordingly.

**May substitute IE 619 (prerequisite IE 627)

***Only one of each bracketed set of courses are counted in the group in which it is listed.
OPERATIONS MANAGEMENT

FACULTY

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Management

Byron L. David, Instructor, 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

ADJUNCT FACULTY

Chaim Steinberger, Adjunct Assistant Professor
OPERATIONS RESEARCH

The department of Transportation and Industrial Engineering offers programs in operations research at the bachelor's, master's and doctoral levels.

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 increasing use of mathematical models in nearly all fields. Trained professionals are needed who can play important roles in the development of quantitative models and solution techniques for challenging problems.

Operations researchers address problems in production, distribution and marketing, allocation of urban resources, industrial and government operations 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 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 this orientation.

UNDERGRADUATE PROGRAM

The undergraduate program leads to the degree of bachelor of science in operations research.

It 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 which build on the core requirements. Some possible elective sequences are listed after the curricula; these are mere suggestions, not required sequences of study.

Students entering this field should normally be prepared 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, give students particularly effective preparation for professional careers.

Laboratories and Computing Facilities

The department operates laboratories in the areas of work design and measurements, human factors, plant layout, robotics, automation, and noise measurement; these laboratories have the latest equipment. Besides direct experimentation, students engage in simulated experimentation and decision making using a broad range of computers.

In addition to the computing facilities described elsewhere in this catalog, the department maintains its own bank of APPLE and IBM-PC computers, as well as direct access and UNIX terminals connecting with the Polytechnic IBM 4341 and DEC-11 computers. Students use existing software packages or may write their own.

Graduate Courses

Qualified juniors and seniors with at least a B average, may take graduate courses as electives, if they 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 they have completed 64 credits equivalent to MA 101-104, PH 101-103, CM 101-102, CM 111-112, CS 100, HU 200, SS 104, SS 251-252, plus 17 credits of acceptable electives, students can complete the requirements shown on pages 218 and 219.

REQUIREMENTS FOR THE DEGREE

BACHELOR OF SCIENCE IN OPERATIONS RESEARCH

<table>
<thead>
<tr>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics MA 101, MA 102, MA 103, MA 104, MA 153, MA 223, MA 224, MA 555 26</td>
</tr>
<tr>
<td>Science CM 101, CM 102, CM 111, CM 112, CS 100, PH 101, PH 102, PH 103 18</td>
</tr>
<tr>
<td>Humanities HU 101, HU 200, SS 104, SS 251, SS 252 15</td>
</tr>
<tr>
<td>Physical Ed PE 101, PE 102, PE 103, PE 104 0</td>
</tr>
<tr>
<td>Major IE 254, IE 300, IE 319, IE 327, IE 328, IE 346, IE 380 21</td>
</tr>
<tr>
<td>Electives Chosen by the student in consultation with department adviser 48</td>
</tr>
<tr>
<td>Total 128</td>
</tr>
</tbody>
</table>

1. 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. Students may substitute CS 111 for CS 100; the extra credit may be counted as technical elective. The adviser may approve the substitution of another statistics course for MA 555.

2. The 48 credits of electives are to be distributed as follows: 12 credits of operations research and industrial engineering, 12 credits of technical electives: engineering or science.

EVENING STUDY

Most courses for the operations research program are available in the evening or late afternoon for the convenience of part-time students. Part-time students usually can finish the program in eight years, without summer work, by averaging eight credits per semester. Students can, however, change their pace readily to suit their educational needs, provided they do not violate prerequisites and Polytechnic time limits.

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>Mathematics MA 101, MA 102, MA 103, MA 104, MA 153, MA 223, MA 224 23</td>
</tr>
<tr>
<td>Science CM 101, CM 102, CM 111, CM 112, PH 101, PH 102, PH 103 16</td>
</tr>
<tr>
<td>Humanities HU 101, HU 110, HU 200, SS 104, SS 251, SS 252 18</td>
</tr>
<tr>
<td>Physical Ed PE 101, PE 102, PE 103, PE 104 0</td>
</tr>
<tr>
<td>Industrial IE 254, IE 300, IE 319, IE 327, IE 328, IE 346, IE 380 21</td>
</tr>
<tr>
<td>Computer CS 111, CS 203, CS 204, CS 205</td>
</tr>
<tr>
<td>Science CS 206, CS 236, CS 237, CS 238, CS 297, CS 299 28</td>
</tr>
<tr>
<td>Electives 6 credits Industrial Engineering 12 credits Humanities/Social Science, 4 credits free 22</td>
</tr>
<tr>
<td>Total 128</td>
</tr>
</tbody>
</table>

1. 15 credits of humanities and social science.
2. 9 credits of free electives: normally any course that does not duplicate others.
3. 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 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 loads per semester to suit their educational needs, provided prerequisites are not violated.

## Freshman Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>Intro. to Computer Progrmg 1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>HU</td>
<td>Writing &amp; the Humanities I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>Calculus I</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>Introductory Physics I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Micro-Economics</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>Physical Education I</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

## Second Semester

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>HU</td>
<td>Writing &amp; the Humanities II</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>Calculus II</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>Introductory Physics II</td>
<td>3½</td>
<td>1½</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>SS</td>
<td>Macro-Economics</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>Physical Education I</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### Freshman Year Notes
- 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.

## Sophomore Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM</td>
<td>General Chemistry I</td>
<td>2½</td>
<td>0</td>
<td>2½</td>
<td></td>
</tr>
<tr>
<td>CM</td>
<td>General Chemistry Lab I</td>
<td>0</td>
<td>1½</td>
<td>½</td>
<td></td>
</tr>
<tr>
<td>IE</td>
<td>Intro. to Industrial Engrg.</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>Appl. Differential Eqns. 1</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PH</td>
<td>Introductory Physics III</td>
<td>2½</td>
<td>1½</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>Physical Education III</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### Sophomore Year Notes
- Electives

## Junior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>Operations Research I</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>IE</td>
<td>System Simulation</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>Intro. to Probability</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

### Junior Year Notes
- Electives

## Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE</td>
<td>Product Planng. &amp; Control</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td>Design of Experiments</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

### Senior Year Notes
- Electives
- Total credits required for graduation: 128
# Typical Course of Study for Transfer Students

## Junior Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>IE 254 Intro. to Industrial Engrg.</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>IE 327 Operations Research</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>IE 380 System Simulation</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MA 223 Intro. to Probability</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Electives¹</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

## Senior Year

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours/Week</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subject</td>
<td>Cl.</td>
<td>Lab.</td>
</tr>
<tr>
<td>IE 319 Prodtn. Plann. &amp; Control</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>MA 555 Design of Experiments¹</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Electives¹</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

Total credits required for graduation: 128
Typical Course of Study for the Degree of Bachelor of Science in Operations Research (Computer Science Option)

A typical program sequence covering eight semesters is shown below. Students may rearrange courses and increase or decrease loads per semester to suit their educational needs, provided prerequisites are not violated.

### Freshman Year

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>Subject</td>
</tr>
<tr>
<td>CS 112</td>
<td>Programming in Pascal</td>
</tr>
<tr>
<td>MA 101</td>
<td>Calculus I</td>
</tr>
<tr>
<td>PH 101</td>
<td>Introductory Physics I</td>
</tr>
<tr>
<td>CM 101</td>
<td>General Chemistry I</td>
</tr>
<tr>
<td>CM 111</td>
<td>General Chem Lab I</td>
</tr>
<tr>
<td>HU 101</td>
<td>Writing &amp; the Humanities I</td>
</tr>
<tr>
<td>PE 101</td>
<td>Physical Education I</td>
</tr>
</tbody>
</table>

Second Semester Hours/Week

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Cl.</th>
<th>Lab.</th>
<th>Cr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 203</td>
<td>Computer Programming II</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>MA 102</td>
<td>Calculus II</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>PH 102</td>
<td>Introductory Physics II</td>
<td>3 1/2</td>
<td>1 1/2</td>
<td>4</td>
</tr>
<tr>
<td>CM 102</td>
<td>General Chemistry II</td>
<td>2 1/2</td>
<td>0</td>
<td>2 1/2</td>
</tr>
<tr>
<td>CM 112</td>
<td>General Chem Lab II</td>
<td>0</td>
<td>1 1/2</td>
<td>1 1/2</td>
</tr>
<tr>
<td>HU 200</td>
<td>Writing &amp; the Humanities III</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>PE 102</td>
<td>Physical Education II</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

### Sophomore Year

<table>
<thead>
<tr>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 204</td>
<td>Intro to Data Structures</td>
</tr>
<tr>
<td>IE 254</td>
<td>Intro to Industrial Engrg.</td>
</tr>
<tr>
<td>MA 104</td>
<td>Appl. Differential Eqs.</td>
</tr>
<tr>
<td>PH 103</td>
<td>Introductory Physics III</td>
</tr>
<tr>
<td>HU 110</td>
<td>Basic Report Writing</td>
</tr>
<tr>
<td>PE 103</td>
<td>Physical Education III</td>
</tr>
</tbody>
</table>

### Junior Year

<table>
<thead>
<tr>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 205</td>
<td>Assem. &amp; Mach. Lang. Prog.</td>
</tr>
<tr>
<td>CS 237</td>
<td>Intro. to Comput. Arch.</td>
</tr>
<tr>
<td>IE 327</td>
<td>Operations Research I</td>
</tr>
<tr>
<td>MA 223</td>
<td>Intro. to Probability</td>
</tr>
<tr>
<td>SS 251</td>
<td>Microeconomics</td>
</tr>
<tr>
<td>Electives</td>
<td>2</td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 238</td>
<td>Computer Systems</td>
</tr>
<tr>
<td>CS 299</td>
<td>Computer Lab II</td>
</tr>
<tr>
<td>IE 319</td>
<td>Prodtn. Planning &amp; Control</td>
</tr>
<tr>
<td>IE 380</td>
<td>System Simulation</td>
</tr>
<tr>
<td>Electives</td>
<td>5</td>
</tr>
</tbody>
</table>

Total credits required for graduation: 128

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* 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 permitted electives to develop meaningful sequences for concentration. Some suggested groupings are shown below from which students may select electives. Courses numbered 600 or above are graduate courses requiring a B or better average and the adviser'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.

### Behavior Credits

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS 175</td>
<td>Introduction to Sociology</td>
</tr>
<tr>
<td>SS 185</td>
<td>Anthropology: Physical</td>
</tr>
<tr>
<td>SS 189</td>
<td>Introduction to Psychology</td>
</tr>
<tr>
<td>SS 191</td>
<td>Social Psychology</td>
</tr>
<tr>
<td>SS 192</td>
<td>Experimental Psychology I</td>
</tr>
<tr>
<td>SS 193</td>
<td>Experimental Psychology II</td>
</tr>
<tr>
<td>SS 198</td>
<td>Psychology of Human Development</td>
</tr>
<tr>
<td>SS 199</td>
<td>Organizational Behavior</td>
</tr>
</tbody>
</table>

### Bioengineering

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BE 201</td>
<td>Systems Approach to Biomedicine I</td>
</tr>
<tr>
<td>BE 202</td>
<td>Systems Approach to Biomedicine II</td>
</tr>
<tr>
<td>CM 122</td>
<td>Organic Chemistry I</td>
</tr>
<tr>
<td>CM 164</td>
<td>Phy.Chem. of Living Systems</td>
</tr>
<tr>
<td>LS 105</td>
<td>General Biology I</td>
</tr>
<tr>
<td>LS 106</td>
<td>General Biology II</td>
</tr>
<tr>
<td>LS 115</td>
<td>General Biology Lab. I</td>
</tr>
<tr>
<td>LS 116</td>
<td>General Biology Lab. II</td>
</tr>
</tbody>
</table>

### Computer Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 203</td>
<td>Computer Programming II</td>
</tr>
<tr>
<td>CS 204</td>
<td>Intro. to Data Structures</td>
</tr>
<tr>
<td>CS 205</td>
<td>Assem. &amp; Mach. Lang. Prog.</td>
</tr>
<tr>
<td>CS 206</td>
<td>Compilers</td>
</tr>
<tr>
<td>CS 236</td>
<td>Switch, Circuits &amp; Digital Syst.</td>
</tr>
<tr>
<td>CS 237</td>
<td>Intro. to Computer Architecture</td>
</tr>
<tr>
<td>CS 238</td>
<td>Computer Systems</td>
</tr>
<tr>
<td>CS 297</td>
<td>Computer Laboratory I</td>
</tr>
<tr>
<td>CS 299</td>
<td>Computer Laboratory II</td>
</tr>
</tbody>
</table>

### Control Systems

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EE 101</td>
<td>Electrical Systems I</td>
</tr>
<tr>
<td>EE 102</td>
<td>Electrical Systems II</td>
</tr>
<tr>
<td>EE 103</td>
<td>Electrical Systems III</td>
</tr>
<tr>
<td>EE 104</td>
<td>Feedback System Principles</td>
</tr>
<tr>
<td>EE 107</td>
<td>Control System Design</td>
</tr>
<tr>
<td>EE 111</td>
<td>Solid-State Devices &amp; Circuits I</td>
</tr>
<tr>
<td>EE 141</td>
<td>Signal Processing</td>
</tr>
</tbody>
</table>

### Economics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>SS 255</td>
<td>The Contemporary Amer. Economy</td>
</tr>
<tr>
<td>SS 257</td>
<td>History of Economic Thought</td>
</tr>
<tr>
<td>SS 258</td>
<td>Comparative Economic Systems</td>
</tr>
<tr>
<td>SS 259</td>
<td>Economic Development</td>
</tr>
<tr>
<td>SS 263</td>
<td>Labor Economics</td>
</tr>
<tr>
<td>SS 264</td>
<td>Urban Economics</td>
</tr>
<tr>
<td>SS 265</td>
<td>Money and Banking</td>
</tr>
</tbody>
</table>

### Management

<table>
<thead>
<tr>
<th>Course</th>
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</tr>
</thead>
<tbody>
<tr>
<td>MG 300</td>
<td>Management Process</td>
</tr>
<tr>
<td>MG 304</td>
<td>Accounting Fundamentals</td>
</tr>
</tbody>
</table>

### Mathematics, Applied

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>MA 153</td>
<td>Elements of Linear Algebra</td>
</tr>
<tr>
<td>MA 154</td>
<td>Elements of Abstract Algebra</td>
</tr>
<tr>
<td>MA 201</td>
<td>Applied Analysis I</td>
</tr>
<tr>
<td>MA 202</td>
<td>Applied Analysis II</td>
</tr>
<tr>
<td>MA 217</td>
<td>Complex Variables</td>
</tr>
<tr>
<td>MA 333</td>
<td>Partial Differential Equations</td>
</tr>
<tr>
<td>MA 358</td>
<td>Intro. to Numerical Analysis</td>
</tr>
</tbody>
</table>

### Operations Research, Advanced

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 153</td>
<td>Elements of Linear Algebra</td>
</tr>
<tr>
<td>IE 618</td>
<td>Inventory Models</td>
</tr>
<tr>
<td>IE 631</td>
<td>Linear Programming</td>
</tr>
<tr>
<td>IE 632</td>
<td>Nonlinear Programming</td>
</tr>
<tr>
<td>IE 650</td>
<td>Queuing Systems I</td>
</tr>
</tbody>
</table>

### Statistics and Probability

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>IE 311</td>
<td>Statistical Quality Control</td>
</tr>
<tr>
<td>MA 232</td>
<td>Statistical Methods II</td>
</tr>
<tr>
<td>MA 238</td>
<td>Applied Probability</td>
</tr>
<tr>
<td>MA 554</td>
<td>Applied Decision Theory</td>
</tr>
<tr>
<td>MA 556</td>
<td>Correlation &amp; Multivariate Models</td>
</tr>
<tr>
<td>MA 557</td>
<td>Sampling</td>
</tr>
<tr>
<td>IE 852</td>
<td>Regression &amp; Analysis of Variance</td>
</tr>
<tr>
<td>IE 853</td>
<td>Design of Experiments</td>
</tr>
</tbody>
</table>

### Transportation Systems

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 350</td>
<td>Logistics</td>
</tr>
<tr>
<td>TR 360</td>
<td>Traffic Planning &amp; Operations</td>
</tr>
<tr>
<td>TR 361</td>
<td>Transportation Demand and Models</td>
</tr>
<tr>
<td>TR 362</td>
<td>Public Transportation</td>
</tr>
<tr>
<td>TR 753</td>
<td>Mgmt. of Transp. &amp; Distrib. Ops.</td>
</tr>
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### Urban Systems

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 346</td>
<td>Oper. Design of Urban Systems</td>
</tr>
<tr>
<td>LS 140</td>
<td>Environmental Biology</td>
</tr>
<tr>
<td>SS 180</td>
<td>Sociology of Urbanization</td>
</tr>
<tr>
<td>SS 182</td>
<td>Man and the Environment</td>
</tr>
<tr>
<td>SS 190</td>
<td>Environmental Psychology</td>
</tr>
<tr>
<td>SS 264</td>
<td>Urban Economics</td>
</tr>
<tr>
<td>TR 600</td>
<td>Char. of Transp. Demand &amp; Syst.</td>
</tr>
<tr>
<td>TR 602</td>
<td>Urban Transportation Planning</td>
</tr>
</tbody>
</table>

### GRADUATE STUDY

The department offers master of science and doctor of philosophy degree programs in 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, queueing 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 the 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. Knowledge of computer programming is assumed. Students lacking this must take IE 531 without credit. 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.

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**REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN OPERATIONS RESEARCH**

**A. Basic Required Courses**

- MA 153 Elements of Linear Algebra
- MA 561 Elements of Probability
- IE 600 Engineering Economy
- IE 608 Statistics
- IE 627 Oper. Res.: Deterministic Models
- IE 628 Oper. Res.: Stochastic Models

**B. Required Courses**

- IE 631 Linear Programming
- IE 632 Nonlinear Programming
- IE 650 Queuing Systems

**C. Major Electives: (Select four courses)**

- IE 611 Statistical Quality Control
- IE 686 Component Reliability
- IE 614 Modeling of Social Systems
- IE 680 System Simulation
- IE 618 Inventory Models
- IE 619 Production Planning & Control
- IE 634 Dynamic Programming
- IE 636 Network Flows & Applications
- IE 720 Optimum Seeking Methods
- IE 851 Stochastic Processes
- IE 852 Applied Regression & ANOVA

**D. Other Relevant Electives**

<table>
<thead>
<tr>
<th>Minimum total</th>
<th>36 units</th>
</tr>
</thead>
</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 are increased accordingly.

2. Only one of each bracketed set of courses will be counted in group C; the other courses may be counted under group D.

3. Group D electives are chosen with advisor'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 502, MG 505, and MG 630.

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*Certain introductory courses will be waived if the student takes specified advanced courses, for which full credit is given.

For IE 627: IE 631 and IE 632
For IE 628: IE 650 and either IE 618 or IE 619
For MA 153: MA 705 or MA 837 or MA 638

*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.

*Students who have not had a full course in statistics are urged to take IE 608 or an equivalent course during the summer preceding their first term.
The disciplines of computer science and operations research complement each other academically and professionally. Any eligible students may pursue master's degrees individually in these two areas. By taking advantage of the reduced credit requirement for a second M.S., however, qualified students can earn the two degrees with a total of 63 credits.

Students whose undergraduate backgrounds are in other scientific and engineering disciplines and who need 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 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 with a considerable saving in credits. Students with superior preparation would have a greater choice of electives.

Students are assigned an adviser in each program. Upon completion, students are 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. Students 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**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 530</td>
<td>Introduction to Computer Science</td>
</tr>
<tr>
<td>CS 540</td>
<td>Elements of Data Structures</td>
</tr>
<tr>
<td>CS 550</td>
<td>Assembly Language Programming</td>
</tr>
<tr>
<td>CS 560</td>
<td>Introduction to Logic &amp; Automata</td>
</tr>
<tr>
<td>CS 580</td>
<td>Introduction to Computer Architecture</td>
</tr>
<tr>
<td>CS 590</td>
<td>Introduction to Operating Systems</td>
</tr>
<tr>
<td>CS 603</td>
<td>Information Structures &amp; Algorithms</td>
</tr>
<tr>
<td>CS 613</td>
<td>Computer Architecture I</td>
</tr>
<tr>
<td>CS 623</td>
<td>Operating Systems I</td>
</tr>
<tr>
<td>CS 637</td>
<td>Programming Languages</td>
</tr>
<tr>
<td>CS 641</td>
<td>Compiler Design &amp; Construction I</td>
</tr>
</tbody>
</table>

Two of the following three:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 614</td>
<td>Computer Architecture II</td>
</tr>
<tr>
<td>CS 624</td>
<td>Operating Systems II</td>
</tr>
<tr>
<td>CS 642</td>
<td>Compiler Design &amp; Construction II</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 153</td>
<td>Elements of Linear Algebra</td>
</tr>
<tr>
<td>MA 561</td>
<td>Elements of Probability</td>
</tr>
<tr>
<td>IE 600</td>
<td>Engineering Economy</td>
</tr>
<tr>
<td>IE 608</td>
<td>Statistics</td>
</tr>
</tbody>
</table>

IE 631 Linear Programming
IE 632 Nonlinear Programming
IE 650 Queueing Systems I
IE 680 System Simulation I

One of the following two:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IE 618</td>
<td>Inventory Models</td>
</tr>
<tr>
<td>IE 619</td>
<td>Production Planning and Control</td>
</tr>
</tbody>
</table>

One course chosen from the bracketed sets in the M.S. (O.R.) program not already represented above: IE xxx

Minimum Total*: 63 credits

**THE DOCTOR OF PHILOSOPHY DEGREE**

The department offers a program leading to the degree of doctor of philosophy in operations research and industrial engineering. The general Polytechnic requirements for doctor of philosophy degrees 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 consists 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 selects a thesis adviser and prepares a formal proposal for the dissertation research. A thesis committee is then appointed to judge the merits of the proposed research. After approval of this proposal, the doctoral candidate registers 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 professionals with work experience. A certificate program requires five courses selected according to the individual's needs. Applicants for a certificate program must hold a bachelor's degree. On completion of the sequence with a B average or better, a certificate is issued. A student who chooses to work towards a master's degree is usually able, on admission, to apply all courses taken for a certificate toward a degree program.

If a student has taken the equivalent of any required course as an undergraduate, or more than one as a graduate student, then substitute courses must be selected in consultation with the adviser. Additional information may be obtained from the department.

The certificate programs are shown below. Additional certificates are shown in the Industrial Engineering section of this catalog.

*If a student must take more than four of the CS 500 series courses, the minimum total number of credits required is increased correspondingly.
Basic Operations Research
MA 153 Elements of Linear Algebra
MA 561 Elements of Probability
IE 608 Statistics

Advanced Operations Research
IE 631 Linear Programming
IE 650 Queueing Systems I
IE 680 System Simulation

Two of the following:
IE 618 Inventory Models
IE 619 Production Planning & Control
IE 632 Nonlinear Programming

Basic Engineering Statistics
MA 561 Elements of Probability
IE 608 Statistics
IE 852 Appl. Regression & ANOVA

Two of the following:
IE 611 Statistical Quality Control
IE 851 Stochastic Processes
IE 853 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 a 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: passing of qualifying examination and guidance committee's approval.

FACULTY

William R. McShane, Professor of Transportation and Industrial Engineering; Head, department of Transportation and Industrial Engineering; Director, Transportation Training and Research Center.
B.E.E., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn; Professional Engineer (New York, California (Traffic))
Traffic Engineering, highway capacity, expert systems in transportation, PC applications and models, economics and finance.

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 approaches, 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

Walter Helly, Professor of 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 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 (New York, Pennsylvania)
Mathematical programming, optimum design, economic evaluation
OPERATIONS RESEARCH

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

ADJUNCT FACULTY

Maureen Dolan, Adjunct Lecturer
B.A., Molloy College; M.S., Stevens Institute of Technology; M.S., Polytechnic Institute of New York

Chaim Steinberger, Adjunct Assistant Professor
M.S., Polytechnic Institute of New York
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, ability and endurance. The program teaches skills in interesting lifetime sports: tennis, racquetball, badminton, as well as innovative programs in aerobics, self-defense, weight training, and cardiopulmonary resuscitation (CPR), and team sports such as volleyball.

Athletics

Student athletes attending Polytechnic compete in a far-reaching intercollegiate athletic program that encompasses all phases of sports. All full-time undergraduate students in good academic standing are eligible to try out for positions on the seven varsity teams which carry the blue and white colors of Polytechnic in N.C.A.A. competition. Intercollegiate sports are men's baseball, basketball, cross-country, soccer, tennis, wrestling, lacrosse, Judo, & women's volleyball, softball, cross-country, and tennis.

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 sound programs of instruction and participation for all students in physical education.

All undergraduate students are required to complete four semesters of physical education in any of the following course offerings:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE 101</td>
<td>Team and Lifetime Sports</td>
<td>0:2:0</td>
</tr>
<tr>
<td>PE 102</td>
<td>Cardiopulmonary Resuscitation and Weight Training</td>
<td>0:2:0</td>
</tr>
<tr>
<td>PE 103</td>
<td>Aerobics</td>
<td>0:2:0</td>
</tr>
<tr>
<td>PE 104</td>
<td>Weight Training</td>
<td>0:2:0</td>
</tr>
<tr>
<td>PE 101S</td>
<td>Self Defense</td>
<td>0:2:0</td>
</tr>
</tbody>
</table>

Note: military science courses (MS 101, 102, 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 Zinaer, Assistant Director of Athletics
B.S., University of Baltimore; M.S., Hofstra University
Physics is the basic science of the natural world — the science of matter, energy and motion. It is indispensable for any engineering or scientific career.

The training of physics majors, at both the undergraduate and graduate levels, is basic and general. This broad preparation makes graduates less subject to the risks of obsolescence produced by the rapidity of technological change in modern life. Curricula are designed to provide backgrounds 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 many different levels. Physics graduates at all levels are employed in private industry, government agencies and research foundations for fundamental research and engineering. Training in physics serves as valuable preparation for any 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, the chemical industry and 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 master’s or doctor’s degree. For many others, it means professional work in industry, government or in high school teaching. Some students use their major in physics as preparation for work in mathematics, chemistry, biology, medicine, engineering, law, history of science, writing, or business.

The program’s emphasis on fundamental knowledge, on thorough analytic training and on the universal logic of science enables physics students to take these different paths.

The structure of the undergraduate program is four-fold: formal instruction in the sciences; instruction in the humanities and social sciences; informal instruction; and additional activities.

Formal instruction in the sciences is described by its program of courses. This program includes — after the freshman year with its beginning courses in physics, chemistry and mathematics — a spiraling 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 students to choose additional courses in these areas. It believes that the natural curiosity which 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. All students meet regularly with members of the physics faculty for informal conferences to discuss their 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, students prepare talks on aspects of advanced topics in physics and present them to the critical audiences of their peers and professors.

Many students spend some time in research, either assisting in the various research programs performed by the faculty or working on relatively independent research projects assigned after consultation with their adviser. Undergraduate participation in research with 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 opportunities for individual reading and advanced study under professional guidance and accepts satisfactory performance in regular course examinations as fulfillment of course requirements.

Physics students have 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 the section of this catalog 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. Such interaction is the most valuable preparation for any careers in physics. This blending of experiences leads to appreciation of the intellectual impact of physics and to understanding why so many important thinkers have been attracted to physics and have added to its achievements.

REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE

The program requires 128 credits, including 56 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 electives. (See Typical Course of Study on the following page.) The distribution is as follows:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH 101-103, 115, 210, 250, 302, 311, 323-324, 334-335, 336, 340, 347, 360, 373, 374, 390</td>
<td>56</td>
</tr>
<tr>
<td>CM 101, 102, 111, 112; MA 101-104, 153, 260, 217; CS 111</td>
<td>33</td>
</tr>
<tr>
<td>HU 101; HU 200 and SS 104</td>
<td>9</td>
</tr>
<tr>
<td>Language (or equivalent)</td>
<td>12</td>
</tr>
<tr>
<td>Electives (6 PH, 12 Hum./Soc. Sci.)</td>
<td>18</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 chosen in consultation with the departmental adviser.

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 offered 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 performed 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 degrees in physics of different emphasis, or with a degree in another field, may be admitted with undergraduate deficiencies if approved by the department adviser. All applicants are requested to take the Graduate Record Examination.

Applicants can apply for 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>No.</th>
<th>Subject</th>
<th>First Semester</th>
<th>Hours/Week</th>
<th>Second Semester</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First Semester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No. Subject</td>
<td>Ct. Lab. Cr.</td>
<td></td>
<td>Ct. Lab. Cr.</td>
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<tr>
<td>CS</td>
<td>112 Programming in Pascal</td>
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<td></td>
<td>CM 101 General Chemistry I</td>
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<tr>
<td>MA</td>
<td>101 Calculus I</td>
<td>4 0 4</td>
<td></td>
<td>CM 111 General Chemistry Lab.</td>
<td>0 1 1/2 1 1/2</td>
</tr>
<tr>
<td>PH</td>
<td>101 Intro. to Physics I</td>
<td>3 0 3</td>
<td></td>
<td>MA 102 Calculus II</td>
<td>4 0 4</td>
</tr>
<tr>
<td>PH</td>
<td>115 Seminar in Current Physics</td>
<td>2 0 2 6</td>
<td></td>
<td>PH 102 Intro. Physics II</td>
<td>3 1/2 1 1/2 4</td>
</tr>
<tr>
<td>PE</td>
<td>101 Physical Education</td>
<td>0 2 0</td>
<td></td>
<td>PE 102 Physical Education</td>
<td>0 2 0</td>
</tr>
<tr>
<td></td>
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<td>18</td>
<td></td>
<td>17</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Hours/Week</th>
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<tbody>
<tr>
<td>18</td>
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</table>

### Sophomore Year

<table>
<thead>
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<th>Hours/Week</th>
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</thead>
<tbody>
<tr>
<td>CM</td>
<td>102 General Chemistry II</td>
<td>2 1/2 0 2 1/2</td>
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<tr>
<td>CM</td>
<td>112 General Chemistry Lab. II</td>
<td>0 1 1/2 1/2</td>
</tr>
<tr>
<td>MA</td>
<td>103 Calculus III</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH</td>
<td>103 Intro. Physics III</td>
<td>2 1/2 1 1/2 3</td>
</tr>
<tr>
<td>PH</td>
<td>2 10 Analyt. Mechanics</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PE</td>
<td>103 Physical Education</td>
<td>0 2 0</td>
</tr>
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</table>

### Junior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
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</thead>
<tbody>
<tr>
<td>PH</td>
<td>311 Thermodynamics</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH</td>
<td>322 Electricity and Magnetism I</td>
<td>2 0 2</td>
</tr>
<tr>
<td>PH</td>
<td>336 Quantum Phys. II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA</td>
<td>260 Vector Anal. &amp; PDE</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
</tr>
<tr>
<td>PH</td>
<td>302 Advanced Lab.</td>
<td>1 3 2</td>
</tr>
<tr>
<td>PH</td>
<td>324 Electricity and Magnetism II</td>
<td>2 0 2</td>
</tr>
<tr>
<td>PH</td>
<td>336 Quantum Mechanics</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH</td>
<td>340 Computer Meth. in Physics</td>
<td>3 4 4</td>
</tr>
<tr>
<td>PH</td>
<td>360 Special Topics</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
</tr>
</tbody>
</table>

### Senior Year

<table>
<thead>
<tr>
<th>No.</th>
<th>Subject</th>
<th>Hours/Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>347 Modern Optics</td>
<td>3 3 4</td>
</tr>
<tr>
<td>PH</td>
<td>373 Intro. Theor. Phys. I</td>
<td>3 0 3</td>
</tr>
<tr>
<td>MA</td>
<td>217 Complex Variables</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH</td>
<td>653 Stat. Mech. II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>3</td>
</tr>
<tr>
<td>PH</td>
<td>667 Quantum Mech. II</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>3</td>
</tr>
<tr>
<td>PH</td>
<td>374 Intro. Theo. Phys. II</td>
<td>3 0 3</td>
</tr>
<tr>
<td>PH</td>
<td>390 Senior Seminar</td>
<td>2 0 2</td>
</tr>
<tr>
<td>PH</td>
<td>654 Stat. Mach. II</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or</td>
<td>3</td>
</tr>
<tr>
<td>PH</td>
<td>668 Quantum Mechanics II</td>
<td>3 0 3</td>
</tr>
<tr>
<td></td>
<td>Hum./Soc. Sci. elective</td>
<td>6 0 6</td>
</tr>
</tbody>
</table>

Electives are chosen with the adviser's approval.

Advanced Electives strongly recommended for students intending to pursue graduate studies in physics. Other possible electives include Advanced Lab. II (PH 303), X-ray Diffraction (PH 372), Readings in Physics (PH 301-2), courses in PH 6 sequence.
REQUIREMENTS FOR THE
MASTER OF SCIENCE DEGREE

The requirements for the master of science degree in physics conform to the general Polytechnic requirements. (see Degree Requirements)

The minimum course requirements for the master's degree are as follows:

<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>Elective Courses</td>
<td></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. Choices of a project or thesis option and 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

Requirements for the Ph.D. degree in physics conform to general Polytechnic requirements. Entrance into the doctoral program of study and research is contingent upon passing the department qualifying examination. The student entering with a bachelor's degree normally takes 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, conducts the dissertation, precis examination and the final dissertation oral examination, and must approve the dissertation, before the degree can be awarded.

The minimum course requirement 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 669-670</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>
<tr>
<td></td>
<td>Additional Physics Courses</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Minor Courses</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Elective Courses or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Additional Research in Physics</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td></td>
<td>90</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. 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 completion of the dissertation, a precis of the proposed work is circulated to the physics faculty and a precis examination held. Upon completion of the dissertation, an oral thesis defense is 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 Departments of Chemistry and Physics, it provides, within the scope of a normal graduate program, an unusual overlap of studies, emphasizing those aspects which are closely related to both fields.

UNDERGRADUATE COURSES

PH 091-092 Concepts of Contemporary Physics I, II each 3:0:4
Topics in both classical and modern physics. Development of physics as a dynamic cumulative process through the interplay of experiment and theory. Co/Prerequisites: MA 091-091.

PH 101 Introductory Physics I 3:0:3
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.

PH 102 Introductory Physics II 3:3:1
Continuation of PH 101. Thermodynamics and kinetic theories 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.

PH 103 Introductory Physics III 2:3:1
Continuation of PH 102. Propagation of waves, particularly as illustrated through studies of physical and geometrical optics. Lab fee required. Prerequisite: PH 102.

PH 115 Seminar in Current Physics 2:0:2
Analysis, lectures, readings and discussions of selected topics of current interest in physics emphasizing concepts and the underlying framework of physical understanding. Topics include astrophysics, atomic and nuclear physics, the solid state and biophysics. Visiting scientists.

PH 210 Analytical Mechanics 3:0:3
PHYSICS

PH 230 Introduction to Atomic and Nuclear Physics 2:0:2
Properties of atoms, nuclei and electrons, photoelectrical 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 250 Electronics for Physical Scientists 3:3:4
Lectures and laboratory on electrical measurements as currently applied in scientific research. Behavior and applications of discrete and integrated solid-state devices in electronic instrumentation. Introduction to measurement of small signals, noise and shielding problems, synchronous detection, and counting techniques. Outlines of digital electronics and descriptions and applications of several interface standards commonly employed for minicomputers in laboratory settings. Prerequisites: PH 103 and MA 103.

PH 281 Astronomy and Astrophysics* 3:0:3
Historical development. Traditional and modern observational techniques. Theories of planets, stars, galaxies. Current advances in astrophysics and cosmology. Given on demand. Prerequisite: PH 103.

PH 302-303 Advanced Lab I, II* 1:3:2

PH 311 Thermodynamics 3:0:3
Experimental bases of fundamental laws of macroscopic thermodynamics. Operational definitions of heat, internal energy, entropy, absolute temperature and other thermodynamic functions. Techniques of deriving and using thermodynamic relations. Prerequisite: PH 334.

PH 323-324 Electricity and Magnetism 2:0:2 each
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 334 Quantum Physics I 2½:1½:3
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 335 Quantum Physics II 3:0:3
Electronic and nuclear structures of the atom. Relativity, wave mechanics, natural and artificial radioactivity, fission, cosmic rays. Fundamental experiments and postulates of wave and particle physics. Prerequisite: PH 230 or PH 334.

PH 336 Quantum Mechanics 3:0:3
Introduction to the calculational methods of quantum mechanics --- with examples and applications. Prerequisite: PH 335.

PH 340 Computer Methods in Physics 2:2:4
Computer methods for solutions and simulations of a wide variety of problems in physics. Numerical methods applicable to problems in mechanics, electromagnetism, optics, statistical mechanics, elementary quantum mechanics and the interpretation of experimental data will be discussed. Strategies to determine if computer results are physically reasonable. Numerical simulation techniques for experimental and theoretical problems. Students have access to microcomputers. Prerequisites: CS 111, PH 210 and PH 323.

PH 347 Modern Optics 3:3:4
The physics of contemporary optics. Reflections and refractions of rays, matrix optics of optical instruments. Interferences and diffractions of waves and wave packets, Fourier transform optics. Coherence and quantum aspects of light. The laboratory includes computer simulations of optical phenomena, and emphasizes lasers, holography, crystal optics, and nonlinear phenomena. Prerequisites: PH 324, PH 336 or equivalents.

PH 360 Special Topics in Physics 3:0:3
Lectures in some specialized area, such as acoustics, biophysics, or relativity. Topics reflect student and faculty interests and vary from year to year. The course may be taken for credit more than once, for different subject offerings. Prerequisites: PH 103, PH 334.

PH 372 X-ray Diffraction 3:0:3
Production and properties of x-rays. Elements of crystallography. Powder and single crystal diffraction techniques. Structures and crystal orientations. Stress analyses and phase and quantitative chemical analyses by x-ray techniques. Prerequisite: MA 104 and PH 103. Also listed under NT 412.

PH 373-374 Introduction to Theoretical Physics I, II 3:0:3

PH 381-382 Reading Course in Physics I, II each 2 credits
Special topics in physics, supervised by 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 students. Prerequisite: PH 336.

PH 391-394 Bachelor's Thesis in Physics each 2 credits
An individual investigation involving theoretical, experimental, and bibliographic studies of some problem of interest to physicists. Students may register for thesis in parts as noted. Total credits determined in consultation with advisers.

PH 399 Senior Honors Work in Physics* credit to be arranged
Independent work undertaken by qualified honor students. Course material arranged by a faculty steering committee.

GRADUATE COURSES

PH 601-602 Physics for Chemists I, II* each 3½:0:4½
For doctoral candidates in chemistry with only a general physics background, 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* 2½:0:3
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 0:3:1½
A range of specialized techniques and processes of modern experimental physics, depending on requirements of thesis students and recommendations of advisers. Vacuum techniques, thin-films, preparation of samples for solid-state studies, crystal growing, cryogenics and instrument design. Intensive training in those particular skills required of student research endeavors. Permission of advisers and director of the course required. May be taken no more than two semesters. Prerequisite: concurrent thesis registration.
PH 607 Mathematical Methods of Physics I*  
2 1/2:0:3  
Vector and tensor analysis. Complex variable theory. Special functions of mathematical physics. Differential equations of mathematical physics. Unifying roles of mathematics in physics on physical concepts and problems. Prerequisites: PH 321 or equivalent and Co/Prerequisite: PH 313 or equivalent.

PH 608 Mathematical methods of Physics II*  
2 1/2:0:3  

PH 612† Microcomputer Instrumentation for Scientific Research*  
2 1/2:0:3  
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  
2 1/2:0:3  
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 618 Theoretical Mechanics II  
2 1/2:0:3  
Hamiltonian mechanics. Transformation theories of mechanics including the Hamilton-Jacobi and Poisson bracket formulation. Lagrangian formulation of mechanics of continuous medium. Prerequisite: PH 615.

PH 624 Electromagnetic Theory I  
2 1/2:0:3  

PH 625 Electromagnetic Theory II  
2 1/2:0:3  
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 ferries; waves in inhomogeneous media. Prerequisite: PH 623.

Also listed under EL 673

PH 633-634† Introduction to Nuclear and Elementary Particle Physics I, II*  
each 2 1/2:0:3  
Fundamental properties of atomic nucleus and its constituents. Two-body problems at low energies and the theory of nuclear forces. Nuclear radioactive processes 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. Prerequisite: PH 693 prerequisite: PH 336. PH 634 prerequisite: PH 633.

PH 635 Biophysics I*  
2 1/2:0:3  
Physical properties of biological systems. Natural properties of biological components. Structural strength, elasticity of beams, muscles, other tissue. Flow properties through tissue, diffusion of gases and liquids, flow through vessels. Compartmental analysis, models, analysis of 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*  
2 1/2:0:3  
Transport processes in 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*  
2 1/2:0:3  
Principles of atomic and molecular physics with stress on the problems of radiation and biological effects of ionizing radiation. Radiation dosimetry including internal and external exposures and relationship between doses, 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 2 1/2:0:3  

PH 663 Statistical Mechanics I  
2 1/2:0:3  

Also listed under EL 651

PH 664 Statistical Mechanics II  
2 1/2:0:3  

Also listed under EL 652

PH 667-668 Quantum Mechanics I, II  
each 2 1/2:0:3  

Also listed under EL 655-656

PH 669-670 Quantum Mechanics III, IV*  
each 2 1/2:0:3  

PH 671 X-ray Diffraction I*  
2 1/2:0:3  
Theory of x-ray scattering and crystallography and crystal optics, diffraction by crystalline materials, space group theory, theory of x-ray diffraction methods, including Laue technique, rotating crystal and moving film methods, single crystal diffractometry. Introduction to powder methods.

PH 672† X-ray Diffraction II*  
2 1/2:0:3  
Interpretations of x-ray powder data. Theories 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 in 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 its applications by amorphous materials. Lab fee required. PH 673 co/prerequisite: PH 671. PH 674 prerequisite: PH 673 and co/prerequisite: PH 672.

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### PHYSICS

**PH 676 Methods of Crystal Structure Determination** 2 1/2: 0: 3
Theory of crystal structure analysis. Trial and error methods, 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** 2 1/2: 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. PH 751 prerequisites: PH 664 and PH 668. PH 752 prerequisite: PH 751.

**PH 753-754 Crystal Dynamics I, II** 2 1/2: 0: 3
Particular physical properties of crystals arising from anisotropy of matter constants. Thermal, electrical, optical, and elastic properties and effects arising from coupling of these properties. Interpretations of these material constants according to modern atomistic theory and principles of crystal symmetry. PH 753 prerequisites: PH 616 and PH 624. PH 754 prerequisites: PH 658 and PH 753.

**PH 761-762 Relativistic Quantum Mechanics and Field Theory I, II** 2 1/2: 0: 3

**PH 763-764 Nuclear Theory I, II** 2 1/2: 0: 3
Fundamental properties of nuclei. Advanced quantum mechanical treatment of nuclear forces, nuclear reactions, nuclear structures, nuclear radiation and the theory of beta-decay. Models of nuclear structure and nuclear reactions. Prerequisite: PH 670 or equivalent.

**PH 765-766 High-energy Physics and Elementary Particle Theory I, II** 2 1/2: 0: 3

**PH 780 Special and General Theory of Relativity** 2 1/2: 0: 3
Einstein’s theory of relativity, Minkowski geometry, relativistic mechanics and electrodynamics, applications of theory with special reference to high-energy physics, gravitational and principle of equivalence. Riemannian geometry, curvature tensor, equations of Einstein’s theory of gravitation, approximate and rigorous solutions, observational tests of the theory, theory of pondersomotive equations. Prerequisites: PH 616 and PH 624 or equivalents.

**PH 801-802 Selected Topics in Advanced Physics I, II** 2 1/2: 0: 3
Current or advanced topics of particular interest to graduate students. Subject matter determined each year by students and faculty. May be given in more than one section. Consult department office for current offerings.

**PH 953-954 Graduate Seminar I, II** 1 1/2: 0: 3
Presentations by participating students and discussion of topics in physics of current interest and from the literature.

**PH 955-956 Reading in Physics I, II** 2 1/2: 0: 3
Selected papers and current literature in a specialized field of physics guided by a faculty member. Prerequisite: graduate advisor’s and supervising faculty member’s permission.

**PH 999 Research in Physics** 3: 0: 3
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 performed under the direction of a member of the department. Chemical physics majors should register for appropriate CM courses. The number of research credits registered for each semester should reflect realistically the time devoted to research. Prerequisites: degree status and graduate advisor’s and research director’s consent.

### FACULTY

**Edward L. Wolf**, Professor and Head of Physics  
B.A., Swarthmore College; Ph.D., Cornell University  
*Solid state physics and electron tunneling*

**Stephen Arnold**, Thomas Potts 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 Kjeldaaas**, 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 Baas**, 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

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

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

Benjamin Post, Professor Emeritus, Research Professor
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 University has had a traditional commitment to strong polymer programs of worldwide renown. At the present time, the Departments of Chemical Engineering and Chemistry jointly offer graduate programs leading to the degrees of master of science and doctor of philosophy in polymer science and engineering.

GRADUATE STUDY

An undergraduate degree in either chemical engineering or chemistry with a mathematics background which includes at least one course in differential equations is usually required for admission to the graduate program. Applicants who have earned bachelor's degrees from foreign institutions are required to submit Graduate Record Examinations and TOEFL scores. 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 degree of master of science is designed to meet the needs of engineers and chemists well versed in the fundamental principles of polymer science and engineering.

REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN POLYMER SCIENCE AND ENGINEERING

Candidates for the degree of master of science in polymer science and engineering are to plan their programs in accordance with the following required courses:

<table>
<thead>
<tr>
<th>No.</th>
<th>Subjects</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<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 Seminar</td>
<td></td>
<td>0</td>
</tr>
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</table>

Chosen Electives* from such courses as: CH 862, CH 917, CH 924, CH 928, CH 933, CH 940-941, CM 700, CM 772, CM 781, CM 782, CM 785, CM 801, CM 905, AM 603-604, AM 606, AM 625, MT 412, MT 603, MT 620, PH 573-674, PH 676

Electives — from above listing 3

or

CH 987 Master's Thesis 9

Total 36

REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN POLYMER SCIENCE AND ENGINEERING

The program for the degree of doctor of philosophy in polymer science and engineering 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 accompanied by study in a minor field chosen by the candidate. Students must pass a comprehensive qualifying examination in polymer science and engineering and present a doctoral dissertation.

All candidates for doctorates must complete a minimum of 90 units of academic work beyond bachelor's degrees, including a minimum of 30 units of dissertation research. Although students 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 students have started dissertations, registration must be continuous (excluding summer sessions) until it is completed and accepted. Of the 90 units, a minimum of 30 units must be taken at Polytechnic. A minimum of 48 graduate units beyond the bachelor's degree (not including Ph.D. thesis) in polymer science and engineering subjects are required, of which at least 18 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. All students must maintain overall B averages in those courses submitted for doctoral degrees.

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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>Polymers</td>
<td>3</td>
</tr>
<tr>
<td>CM 783</td>
<td>Laboratory Methods in Polymer Chemistry</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 21

Students interested in the Ph.D. program should obtain brochures outlining procedures and requirements, available from the office of the polymer science and engineering program director.

**GRADUATE COURSES**

**CH 862 Rheology of Non-Newtonian Fluids**

2½:0:3

Classifications of non-Newtonian viscoelastic fluids. Derivation of rheological equations of state from continuum mechanics points of view. Molecular viscoelastic theories will be discussed. Experimental characterizations of non-Newtonian fluids; steady and dynamic experiments, measurements of normal stress differences in shear flow. Engineering applications to polymer processing operations. Prerequisite: CH 631, MA 931 and MA 532 or equivalent.

**CH 917 Introduction to Polymeric Materials**

2½:0:3

Principles of technological aspects of polymerization, compounding and processing of polymeric materials, their properties and applications. Thermoplastic materials such as polyethylene, polypropylene, polyvinyl chloride, polystyrene, acrylics and engineering plastics are discussed. Thermosetting materials covered include phenolics, epoxies, unsaturated polyesters, aminoplastics, polyurethanes and silicones. Prerequisite: CH 123 or equivalent.

**CH 921 Polymer Processing**

2½:0:3

Applications of engineering principles of polymer processing. Non-Newtonian polymeric systems, Extrusion theory and applications, Discussions and problem-solving in injection molding, fiber spinning, film blowing, and co-extrusion, as well as other polymer engineering processes. Prerequisites: CH 220 and CH 221 or instructor's permission.

**CH 923 Polymer Processing Laboratory**

0:4:3

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, blowing. Prerequisite: CH 921.

**CH 924 Polymerization Reaction Engineering**

2½:0:3

Principles of polymerization reactions, such as chain polymerization and heterogeneous polymerization reactions, from engineering points of view, including mixing and thermal effects. Mathematical modeling techniques for describing molecular weight moments. Copolymer composition and sequence distribution. Principles of polymer reactor design. Model parameter estimation and reactor control. Prerequisite: CH 921 or equivalent.

**CH 926 Engineering Properties of Polymers**

2½:0:3


**POLYMER SCIENCE AND ENGINEERING**

**CH 928 Polymer Composites**

2½:0:3

Production, properties and durability of polymer composites. Emphasis on fiber-reinforced thermosets. Chemical compositions, cure kinetics, processing, viscoelasticity and fracture mechanics. Behavior of composites in service analyzed in terms of their structures. Prerequisites: CH 921, CH 926.

**CH 933 Coatings Technology**

2½:0:3


**CH 940-941 Selected Topics in Polymer Science and Engineering I, II**

2½:0:3

Topics of special interest in polymer science and engineering are announced in advance of each semester offering. Prerequisite: advisor's approval.

**CM 771 Introductory Polymer Chemistry**

2½:0:3

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 study, properties of commercial polymers. Prerequisites: CM 123, CM 125 and CM 162.

**CM 772 Syntheses of High Polymers**

2½:0:3


**CM 781 Solution Properties of High Polymers**

2½:0:3

Applications of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, 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. Synthetic and biological macromolecules are covered. Prerequisites: CM 161, MC 162, and CM 771 or CM 783.

**CM 782 Macromolecules in the Solid State**

2½:0:3

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 of 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**

2½:0:3

Presentation at intervals of various advanced or specialized topics in polymer chemistry.

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POLYMER SCIENCE AND ENGINEERING

PROJECTS, THESSES AND SEMINARS

CH 930  Guided Studies in Polymer Science and Engineering  8 units, each 2 units
Presentations of a comprehensive report of some problems involving polymer science and engineering, such as polymer synthesis, processing, evaluation, or equipment design is required. Candidates for master's degree are required to submit three unbound copies of typewritten project reports 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 investigations of problems in polymer science and engineering. Theses may involve experimental research, theoretical analyses, or process designs, and possibly a combination thereof. Candidates for master's degree are required to submit four typewritten unbound thesis copies to advisers the week before or on the seventh Wednesday prior to commencement. Prerequisite: degree status.

CH 999  Dissertation for Degrees of Doctor of Philosophy in Polymer Science and Engineering  30 units, each 3 units
Dissertation must give results of independent investigations of problems in polymer science and engineering and may involve experimental and/or theoretical work. Thesis must show original contributions to polymer science and engineering worthy of publication in recognized journals. The candidate is required to take an oral examination on subject of thesis and on related topics. Candidates for a doctor's degree are required to submit five unbound thesis copies to advisers before or on the 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  0:2½:0
Recent developments in the field of chemical engineering or polymer science and engineering will be presented through lectures given by engineers from industry, research, and educational institutions, by staff members, or 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

Frederick Eirich, Distinguished Professor of Polymer Chemistry

T.K. Kwei, Research Professor of Polymer Chemistry

Herbert Morawetz, Institute Professor

Yoshiyuki Okamotor, Professor of Chemistry

Eli M. Pearce, Professor of Polymer Chemistry and of Chemical Engineering, Dean of Arts and Sciences

Arnost Reiser, Research Professor and Deputy Director of the Institute for Imaging Sciences

William H. Starnes, Professor of Polymer Chemistry, Head of Chemistry

Giuliana Tesoro, Research Professor of Chemistry

Otto Vogl, Herman F. Mark Professor of Polymer Chemistry

Mary K. Cowman, Associate Professor of Biochemistry

Jovan Mijovic, Associate Professor of Chemical Engineering

William T. Winter, Associate Professor of Polymer Chemistry
SOCIAL SCIENCES

UNDERGRADUATE PROGRAMS

Programs in Social Sciences consist of a core curriculum in Contemporary Liberal Arts and course concentrations in History, History of Science, Economics, Behavioral Science, and Psychology. Core curricula were conceived to meet increasing needs for specialists in the social sciences who are familiar with computers, the physical sciences, mathematics and the humanities. Students are offered specialized training in the social sciences in settings noted for their scientific and technical excellence. Degrees are interdisciplinary, with emphasis on developing integrated historical, economic, behavioral and cultural perspectives on human society and behavior.

Social science backgrounds are useful in teaching at all levels; in applied research on problems involving race, poverty, and education; urban and national planning; management, personnel operations and market research; environmental impact evaluation; foreign policy assessment; law; and medicine. Social science degrees provide an excellent basis for further education and advanced professional training. Graduates are employed in government agencies, foundations, private industry, and independent practice.

The department is also responsible for the social science courses which provide general education and professional training for scientists and engineers at Polytechnic. Foundations in the social sciences prepare students for leadership in industry, education, and government.

HISTORY AND THE HISTORY OF SCIENCE AND TECHNOLOGY

Courses in history emphasize elements of social and economic change in various areas and periods since the Renaissance. Methods and conclusions of related work in economics and the behavioral sciences are applied. Basic sequences in the history of western civilization familiarize students with political, economic, social, cultural and intellectual developments in European history since the Middle Ages. They also introduce them to original documents and scholarly interpretations. Science and technology have been pivotal in modern historical development and social change, especially in our own epoch, and are emphasized in all introductory courses. An introductory course on the modern world stresses the conflicts of ideologies in the twentieth century and the history of non-Western societies. Students analyze and discuss the best historical scholarship with 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 varied and include formal lectures, discussions, colloquia, films, and tutorials leading to independent research. Students can major in the history of science and technology and benefit from one of the most comprehensive programs available in the New York area. Career openings include law, medicine, teaching, public relations, and all fields of media and communications.

ECONOMICS

Economics courses guide students in developing critical understanding of contemporary economic ideas and their roots, institutions and problems. These courses pose, in their theoretical and historical contexts, important questions of domestic and international public policy.

 Majors in economics receive thorough grounding in the tools of economic analysis, mathematics, and statistical methods. Concentration in economics prepares students for careers in governmental service, business and graduate work, not only in economics but in any of the social sciences. Theoretical training is applied to actual economic problems and circumstances.

BEHAVIORAL SCIENCES

Introductory courses in anthropology, politics, sociology, psychology and environmental psychology broaden students' understanding of social processes and human behavior and prepare them to meet professional and administrative problems with insight and sophistication. For students majoring in behavioral sciences, advanced courses provide detailed and intensive study. These courses examine contemporary American society and its impact on the individual, the variety of social and cultural forms which have unfolded in the course of history and their implications for the contemporary world as new nations enter the historical mainstream, and language, learning, and the modification of behavior with experiments in psychophysics, learning theories and communications. Students have opportunities to become acquainted with the range of behavioral science methods, from participant observation and structured interviewing to opinion sampling, psychological testing and controlled laboratory experiments.

PSYCHOLOGY

Courses introduce students to psychology as the science of behavior and emphasize that learning is an active process which can be empirically investigated. The department offers advanced courses in social, developmental, personality, comparative, physiological, learning and abnormal psychology. The major focus is experimental, and all majors take a two-semester laboratory sequence, which offers fundamental methods and concepts in the empirical investigation of human and animal behavior. Other psychology courses allow ample opportunities for students to design and complete individual research projects under the supervision of instructors. A concentration in psychology enables students to pursue graduate training in psychology and other fields including psychotherapy, social work, marketing research, personnel management, organizational behavioral, and social impact assessment.
REQUIREMENTS FOR THE BACHELOR'S DEGREE IN SOCIAL SCIENCES

Core Curriculum

For a full description of courses available in the Contemporary Liberal Arts Core Curriculum see . These courses may be used to fulfill requirements for Bachelor of Science degrees in social sciences.

MAJOR CONCENTRATIONS

(Students may choose from the following courses to fulfill requirements for major concentrations.

History

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>SS 110</td>
<td>Renaissance and Reformation Era</td>
</tr>
<tr>
<td>SS 115</td>
<td>History of Africa</td>
</tr>
<tr>
<td>SS 116</td>
<td>History of Latin America</td>
</tr>
<tr>
<td>SS 120</td>
<td>History of Tsarist Russia to the Revolution</td>
</tr>
<tr>
<td>SS 121</td>
<td>History of the Soviet Union</td>
</tr>
<tr>
<td>SS 123</td>
<td>History of the United States: From Settlements to Reconstruction</td>
</tr>
<tr>
<td>SS 124</td>
<td>History of the United States: From Reconstruction to the Cold Wars</td>
</tr>
<tr>
<td>SS 125</td>
<td>American Radicalism and Reform</td>
</tr>
<tr>
<td>SS 126</td>
<td>Afro-American History</td>
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<tr>
<td>SS 127</td>
<td>American Economic History in the Industrial Era</td>
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<tr>
<td>SS 128</td>
<td>History of Jazz</td>
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<tr>
<td>SS 129</td>
<td>Growth of the United States Constitution</td>
</tr>
<tr>
<td>SS 130</td>
<td>The American Revolution</td>
</tr>
<tr>
<td>SS 132</td>
<td>Problems of American Foreign Policy</td>
</tr>
<tr>
<td>SS 144</td>
<td>Colloquium in the Intellectual History of Europe during the 19th Century</td>
</tr>
<tr>
<td>SS 145</td>
<td>Colloquium in 20th Century Thought</td>
</tr>
<tr>
<td>SS 147</td>
<td>Colloquium in Imperialism</td>
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<tr>
<td>SS 148</td>
<td>Colloquium in the History of Socialism and Communism</td>
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<tr>
<td>SS 149</td>
<td>Colloquium in the History of Marxism</td>
</tr>
<tr>
<td>SS 153</td>
<td>Revolutions in Comparative Historical Perspective</td>
</tr>
<tr>
<td>SS 154</td>
<td>Russia, China, and the West</td>
</tr>
<tr>
<td>SS 161</td>
<td>Politics and Film</td>
</tr>
<tr>
<td>SS 179</td>
<td>Sociology of Human Diseases</td>
</tr>
<tr>
<td>SS 622</td>
<td>Theory and History</td>
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</tbody>
</table>

Behavioral Sciences

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>SS 139</td>
<td>Psychological Forecasting</td>
</tr>
<tr>
<td>SS 157</td>
<td>Topics in Comparative Politics I</td>
</tr>
<tr>
<td>SS 158</td>
<td>Topics in Comparative Politics II</td>
</tr>
<tr>
<td>SS 177</td>
<td>Social Problems</td>
</tr>
<tr>
<td>SS 178</td>
<td>Minorities in the New World</td>
</tr>
<tr>
<td>SS 179</td>
<td>Sociology of Human Disease</td>
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<td>SS 180</td>
<td>Sociology and Urbanization</td>
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<tr>
<td>SS 182</td>
<td>Man and the Environment</td>
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<td>SS 187</td>
<td>World Prehistory</td>
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<td>SS 188</td>
<td>Social Change and Evolution</td>
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<td>SS 190</td>
<td>Environmental Psychology</td>
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<td>SS 191</td>
<td>Social Psychology</td>
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<td>SS 196</td>
<td>Psychology of Stress and Relaxation</td>
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<td>SS 197</td>
<td>Personality Development</td>
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<td>SS 198</td>
<td>Psychology of Human Development</td>
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<td>SS 199</td>
<td>Organizational Behavior</td>
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<td>SS 203</td>
<td>Learning</td>
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<td>SS 204</td>
<td>Physiological Psychology</td>
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<td>SS 205</td>
<td>Comparative Psychology</td>
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<tr>
<td>SS 211</td>
<td>Cultural Backgrounds of African Nations</td>
</tr>
<tr>
<td>SS 212</td>
<td>Cultural Backgrounds of the Nations of Asia</td>
</tr>
<tr>
<td>SS 213</td>
<td>History and Culture of Americans Called Indians</td>
</tr>
<tr>
<td>SS 310</td>
<td>Genes, Gender, and Society</td>
</tr>
<tr>
<td>SS 631</td>
<td>Seminar in Sociology of Science</td>
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Psychology

<table>
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<tbody>
<tr>
<td>SS 190</td>
<td>Environmental Psychology</td>
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<tr>
<td>SS 191</td>
<td>Social Psychology</td>
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<tr>
<td>SS 192</td>
<td>Experimental Psychology I (required)</td>
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<tr>
<td>SS 193</td>
<td>Experimental Psychology II (required)</td>
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<tr>
<td>SS 194</td>
<td>Drugs and Behavior</td>
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<td>SS 195</td>
<td>Abnormal Psychology</td>
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<td>SS 196</td>
<td>Psychology of Stress and Relaxation</td>
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<td>SS 197</td>
<td>Personality Development</td>
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<tr>
<td>SS 198</td>
<td>Psychology of Human Development</td>
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History of Science and Technology

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>SS 135</td>
<td>History of Science and Technology: Antiquity to Galileo</td>
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<tr>
<td>SS 136</td>
<td>History of Science and Technology: Galileo to Darwin</td>
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<tr>
<td>SS 137</td>
<td>History of Science and Technology: Faraday to the Present</td>
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<td>SS 138</td>
<td>Technology, Science, and Contemporary Society</td>
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<td>SS 139</td>
<td>Technological Forecasting</td>
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<td>SS 140</td>
<td>Science and Technology in America</td>
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<tr>
<td>SS 602</td>
<td>Seminar in the History of Science</td>
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<tr>
<td>SS 615</td>
<td>Guided Reading in the History of Ideas</td>
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<tr>
<td>SS 616</td>
<td>Guided Reading in the History of Science</td>
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<tr>
<td>SS 620</td>
<td>History of Biology</td>
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<tr>
<td>SS 621</td>
<td>Development of Physical Theory from Maxwell to Einstein</td>
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<td>SS 622</td>
<td>Theory and History</td>
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<tr>
<td>SS 625</td>
<td>History of Technology: Antiquity through Early Industrial Revolution</td>
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<tr>
<td>SS 626</td>
<td>History of Technology: Industrial Revolution to the Present</td>
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<tr>
<td>SS 631</td>
<td>Seminar in the Sociology of Science</td>
</tr>
<tr>
<td>SS 635</td>
<td>History of Psychology</td>
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</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 200.*

*History and History of Science options may be combined.
The master's and part-time programs are offered at the Brooklyn campus of Polytechnic. The Department of Social Sciences offers the master of science degree in Environment-Behavior Studies, an area which combines expertise in the behavioral sciences and design professions.

The program is designed for students from a variety of backgrounds who can combine their abilities and past experiences with programs available at Polytechnic to develop skills to deal with environmental problems.

Students plan individualized programs in consultation with faculty advisers consisting of a series of basic courses and a number of electives to develop expertise in behavioral science research methods and areas of specialization which reflect their own backgrounds and interests.

In addition to courses in Environment-Behavior studies, these electives may include courses given in other programs offered at Polytechnic such as transportation planning, solar energy, or environmental impact assessment. Program requirements also include a master's thesis.

These programs enable students to become environmental professionals capable of addressing socio/technical problems in a variety of research and applied settings. Students with design, technical, or scientific expertise are especially encouraged to apply.

Full- and part-time programs are offered at the Brooklyn campus of Polytechnic.

**Types of Programs**

**Behavioral Approaches to Architectural Programming and Evaluation.**

Students interested in this area of specialization will learn to use behavioral research and analysis techniques to evaluate the successes and failures of a setting (interior or exterior spaces) in meeting designer goals and user needs. They will also learn how to use data gathering methods in developing functional programs for spaces.
SOCIAL SCIENCES

Human Factors in Large Scale Engineering Systems
Applications of principles of psychological research and evaluation techniques to large scale environmental design projects.

Behavioral aspects of transportation planning, and behavioral analysis of energy use.
Electives for programs within these areas may be chosen from the listed courses as well as courses in the Departments of Transportation Planning, Social Sciences, and Operations Research. Interaction is possible with the Energy Engineering and Policy Program.

Social Impact Assessment (with a minor in environmental engineering).
Theoretical basis and practical applications of social research for the analysis and appraisal of planned changes in areas such as transportation, energy, natural resources, housing and community development, education and health, all of these, in the contexts of technology assessment, environmental impact assessment, risk assessment and cultural resources management.

Electives for this program may include the listed courses, and courses from Social Sciences, the History of Science and Technology Program, Industrial Engineering and Operations Research, Civil and Environmental Engineering, Humanities, and Management as well, and also may include cooperation with the Environmental Health Science Program.

Psychology and the Uses of New Technologies in the Workplace
Students focus upon physical and behavioral factors affecting the utilization of new technologies in the workplace, including the impacts of new computer and telecommunications technologies on the job. Students utilize behavioral and psychophysical techniques to assess user responses to changes in communication networks, systems, and software. They develop assessment skills for environmental and organizational changes caused by new technologies. This new concentration is designed for planners, interior designers, architects, programmers and systems analysts, and people involved in designing office technologies.

Laboratory Research in Environmental Effects.
Students who choose this specialty are trained to use laboratory techniques and facilities to study the effects of various environmental stresses on behavior under controlled conditions. The range of stresses which may be studied include crowding, noise pollution, electrical fields, building vibration, excessive light and heat, and air or water pollution. Effects to be monitored may include physiological measures such as sleep patterns, blood pressure, gastric pathology, and behavioral measures such as performance on learning tasks and reported levels of comfort. Electives for these programs may include listed courses as well as courses from the Department of Civil and Environmental Engineering and Mechanical and Aerospace Engineering.

Certificate Program
Students may take a five courses sequence for a certificate in Environment-Behavior Studies. The program

is available as a minor for students in other programs, or for students applying directly for the certificate.

Degree Requirements

Core Courses in Environment-Behavior Studies (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

Thesis (6 units)
SS 997—Master’s Thesis — 6 units. In addition to writing a thesis, students are encouraged to do practicum work in their areas of specialization.

Electives (5 units). Students may take up to 5 units of electives from a variety of departments, three of which must be chosen from advanced courses in Environment-Behavior studies.

Typical Programs:

For “Behavioral Approaches to Architectural Programming and Evaluation” Program

• 5 Core Courses
• Advanced Courses:

Post Occupancy Evaluation (SS 928)
Social Impact Assessment (SS 924)
Stress and the Environment (SS 928)
Human Factors in Engineering (1E 765)

• Master’s Thesis

For “Social Impact Assessment” Program

• 5 Core Courses
• Advanced Courses:

Social Impact Assessment (SS 924)
Behavioral and Special Aspects of Transportation Planning (SS 916)
Environmental Impact Evaluation (CE 767)
Environmental Health Engineering (CE 751)

• Master’s Thesis

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
SS 101-102 provide an 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 heritages of Western society from approximately 1500 to 1914. May be taken independently.
SS 104 Main Themes in Contemporary World History 3:0:3
Major sources of change, transformations and tensions in this century. Discussions, readings, lectures, films on war, racism, scientific-technical revolutions, socialism, communism, imperialism, the United States and revolutionary movements, modernization of underdeveloped societies, cold wars and current crises.

SS 110 The Renaissance and Reformation* 3:0:3
Dynamic changes in intellectual and artistic values, political and economic approaches, social and religious institutions from late Middle Ages to counter-Reformation. Guided readings and research. Discussions of selected topics.

SS 115 History of Africa* 3:0:3
Pre-colonial African history; origin of man; Egypt, Ethiopia, Kush and Southwest Asian ties; medieval West African kingdoms and trade across Sahara; coastal trading cities of East Africa, India, China. Slave trade; European conquest; struggles for independence. Contemporary African states in world politics.

SS 116 History of Latin America* 3:0:3
Early Mexico and Andean areas, Spanish conquests and establishment of hacienda systems throughout Latin America. Wars of independence. Social, cultural and political developments of last century. Latin America and United States.

SS 120 History of Tsarist Russia to the Revolution 3:0:3
Russian state and society from earliest times; structure and practice of Tsarism; Russia as "underdeveloped" society, special problems of modernization; Russia and West; Culture and literature with special emphasis on 19th century fiction. Political, social, economic causes of Revolution in 1905.

SS 121 History of Soviet Union 3:0:3
Revolution of 1917; Leninism in power; industrialization, collectivization, ascendency of Stalin; Soviet Union and West—from alliance to Cold War; Khrushchev and co-Stalinism; Soviet impact on underdeveloped world; contemporary trends in Soviet society.

SS 123 History of the United States: From Settlements through Reconstruction 3:0:3
Culture, politics and society from early European and Afro-American settlements through post-Civil War era. Interpretation of available documentary sources, with special emphasis on problems of changing relations between whites and native Americans from the 17th through the mid-19th century.

SS 124 History of the United States: From Reconstruction through the Cold War 3:0:3
The emergence of provincial America to global authority; interweaving domestic struggles and foreign policies as United States moves from "Gilded Age" through Progressive Era, World Wars of the 20th century, The New Deal period through revolutionary upheavals in the post-World War II epoch.

SS 126 Afro-American History* 3:0:3
Roles of black people in history: African cultural background, slavery as an institution; abolition movement, Civil War, reconstruction, segregation, migrations, politics, African independence. Black Americans now and their future.

SS 127 American Economic History in the Industrial Era 3:0:3
The United States from late 19th century to present: rise of industry; closing of frontiers; progressive era; Great Depression and New Deal, World Wars and aftermath. Particular attention to economic roles of government.

SS 128 A History of Jazz* 3:0:3
History, appreciation and analyses of jazz as unique Afro-American art form. Social and historical roots and interactions with other musical traditions. Contemporary trends as expressions of 20th century society and culture.

SS 129 Growth of the United States Constitution* 3:0:3
Growth and unfolding of American constitutional system stressing political and economic factors shaping the law. Students handle leading court decisions and related legal texts.

SS 130 The American Revolution* 3:0:3
Origins, nature and consequences of American Revolution: growing struggle with Great Britain after 1760; military history of revolution—guerrilla versus conventional warfare, Political and economic history of revolution; roles of nationalists and libertarians; aftermath and consequences.

SS 132 Problems of American Foreign Policy* 3:0:3
Formulations and applications of foreign policy from 18th-century through post-Cold War; continental and overseas expansions, international rivalries; impacts of domestic influences; diplomacy of infant republic; Monroe Doctrine; "manifest Destiny;" "white man's burden," open-door policy; "dollar diplomacy;" World Wars and their settlements; Cold War and aftermath.

SS 135 History of Science and Technology: Antiquity through Galileo 3:0:3
Science and technology from earliest time to Renaissance: neolithic and medieval technologies; achievements of ancient Greeks from pre-Socrates to Euclid; Copernican revolution; science and technology in expansion of Europe; influences of science on development of European thought.

SS 136 History of Science and Technology: Galileo through Darwin 3:0:3
Science and technology from the scientific revolution through Voltaire to the origins of the Theory of Evolution. Galileo and Newton; the beginnings of evolutionary thought; the organization of scientific inquiry; the impact of scientific thought on society in the 17th, 18th and early 19th centuries; connections between technology and science.

SS 137 History of Science and Technology: Faraday through the Present 3:0:3
Science and technology from early 19th century forward: the maturation of evolutionary thought and its consequences; the rise of the sciences of electricity and heat, relativity, quantum mechanics; the development of cell theory, genetics and biochemistry.

SS 138 Technology, Science, and Contemporary Society* 3:0:3
Mutual relationships between technology, science and society; emergence of "big science;" national styles in science and technology; social effects of recent technological and scientific developments; policy issues posed by restricted and unrestricted uses of technology and science.

SS 139 Technological Forecasting 3:0:3

SS 140 Science and Technology in America* 3:0:3

SS 144 Colloquium in Intellectual History of 19th-Century Europe* 3:0:3
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.
SOCIAL SCIENCES

SS 145 Colloquium in Twentieth-Century Thought 3:0:3
Contemporary ideas of Europe and America. Reading and evaluation of selected works in political theory, economic theory, philosophy of science, historiography, ethics, aesthetics, and mass cultures.

SS 147 Colloquium in Imperialism 3:0:3
Principal theories of imperialism establishing their premises, their internal consistency, and their historical validity since dissolution of world empires after World War II. Students establish their own criteria and judgements. Prerequisites: SS 104 or equivalent.

SS 148 Colloquium in The History of Socialism and Communism* 3:0:3
Socialist movements from founding of Second International to collapse in 1914 and revival in interwar years. Communist movements 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 sources in translation.

SS 149 Colloquium in the History of Marxism* 3:0:3

SS 151 Introduction to Politics* 3:0:3
Major issues in history of political philosophy: the state; nature of political obligation; scope of dissent. Origins and functions of American political system. Clashing ideologies of democratic society.

SS 153 Revolutions in Comparative Historical Perspective* 3:0:3

SS 154 Russia, China, and the West* 3:0:3

SS 157-158 Topics in Comparative Politics* each 3:0:3
Analyses and research of 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 Politics and Film 3:0:3
Film viewed as document and instrument of social structures and relations. Film as facet of mass culture and mass communication and 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; the Fall of France, 1930-1940; Great Britain - the End of Empire, Russia in Revolution and Civil War, the Reconstruction of Europe, 1947-1982. Film screenings, readings, lectures and discussions. Lab fee required. May be repeated for credit.

SS 175 Introduction to Sociology 3:0:3
Influences of culture and social structures on human behavior. 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
Social disorganization and deviant behavior in contemporary society: crime and juvenile delinquency; mental disorder; drug addiction; alcoholism; suicide; family disorganization; poverty; and unemployment. Comparisons with cultures of other peoples and/or simpler societies. Discussions 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. Spanish-speaking minorities of Puerto Rican and Mexican descent in United States compared with ethnic and racial counterparts in Puerto Rico, Cuba, and Brazil.

SS 179 The Sociology of Human Disease* 3:0:3
Human disease in contexts of social and biological adaptation. Disease profiles of the three major levels of man's social evolution — hunters and gatherers, low-energy agriculturists, and states-considered from broadly conceived human ecological viewpoints. Recommendation: some background in biology and anthropology.

SS 180 Sociology and Urbanization* 3:0:3
Origins and history of urbanization, ecology of contemporary cities and urban-rural relations, urbanism, family patterns, personality development, Social-economic stratification, distribution of power, comparative analyses of urbanization in non-Western world. Student projects on urban problems.

SS 182 Man and the Environment 3:0:3
Ecological understanding of interactions of humans with nonhuman environments through relevant topics: ecosystem, human interaction with ecosystem, human societies as self-regulating systems, attitudes toward nature, case studies in ecological history, present environmental crises and attempts at resolutions.

SS 183 History and Environment 3:0:3
Changing human environmental support systems and societal and technological responses at three critical historical junctures: the ancient world; the early modern period; and the twentieth century. Discussions focus on current environmental issues.

SS 185 Anthropology: Physical 3:0:3
Biocultural bases of human conduct seen in evolutionary perspectives; elementary genetic, demographic and ecological models necessary for understanding of human behavior; biology as an evolutionary complex extending from the primordial revolution through the neolithic revolution.

SS 186 Anthropology: Cultural 3:0:3
Social evolution from the hunting and gathering band through state society. Considerations of variation and developmental trends in several human institutions: kinship; economic organization; warfare, politics, religion; and technology. Demographic and ecological variables receive primary stress.

SS 187 World Prehistory* 3:0:3
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.
**SOCIAL SCIENCES**

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
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<tbody>
<tr>
<td>SS 188</td>
<td>Social Change and Evolution*</td>
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<td>Theories of social change, &quot;evolutionary&quot; versus &quot;functionalist&quot; 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.</td>
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<tr>
<td>SS 189</td>
<td>Introduction to Psychology</td>
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<td></td>
<td>Scientific study of behavior, learning, physiologial psychology, sensory systems, developmental, educational, abnormal and social psychology. Lectures, class discussion, films, demonstrations of experiments.</td>
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<tr>
<td>SS 190</td>
<td>Environmental Psychology</td>
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<td>Ways people use and are affected by their physical environments. Research in natural environments as well as built urban areas. Research on personal space, privacy, territoriality, crowding and design-behavior relationships. Field research to assess suitability of environments to human needs, using interview techniques, behavioral observations and unobtrusive measures. Prerequisite: SS 189 or equivalent.</td>
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<tr>
<td>SS 191</td>
<td>Social Psychology</td>
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<td></td>
<td>Behavior as function of social stimulation. Nature of sociopsychological inquiry, with 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 189.</td>
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<tr>
<td>SS 192</td>
<td>Experimental Psychology I*</td>
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<tr>
<td>SS 193</td>
<td>Experimental Psychology II*</td>
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<td></td>
<td>Complex learning and verbal behavior. Students design, complete and analyze experiments dealing with learning verbal responses, concept formations, communication nets and perform original experiments designed with help of instructor. Laboratory reports required. Lectures on substance and methods of experiments. Prerequisite: SS 192.</td>
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<tr>
<td>SS 194</td>
<td>Drugs and Behavior</td>
<td>3:0:3</td>
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<tr>
<td>SS 195</td>
<td>Abnormal Psychology*</td>
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<td>Types of abnormal behavior: neurosis, psychosis, psychosomatic reactions, character disorders. Developmental and social learning theories, biological, etiological models. Relations of methods of treatment of abnormal behavior to models of etiology. Prerequisite: SS 189.</td>
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<tr>
<td>SS 196</td>
<td>Stress and Relaxation*</td>
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<td>Behavioral, physiological and anatomical changes which result from stress and relationships between stress and disease. Techniques of reducing stress and anxiety; Jacobson's relaxation technique, meditation, yoga and biofeedback. The laboratory gives students opportunities to measure the subject's behavioral and physiological responses to stress and anxiety and to practice relaxation techniques including yoga and biofeedback training. Prerequisite: SS 189.</td>
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<tr>
<td>SS 197</td>
<td>Personality Development*</td>
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<td></td>
<td>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 189.</td>
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<tr>
<td>SS 198</td>
<td>Psychology of Human Development*</td>
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<td>Human development from birth to old age. Effects of age on thinking, learning, social behavior. Implications for teaching and educational programs. Prerequisite: SS 189.</td>
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<td>SS 199</td>
<td>Organizational Behavior*</td>
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<td>Behavior in industrial settings. Imitation and formal group dynamics: interpersonal relationships, supervision, leadership, communication theories, attitude measurement, creativity. Analyses of administration problems through case studies and simulated situations. Prerequisite: SS 189.</td>
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<tr>
<td>SS 203</td>
<td>Psychology of Learning*</td>
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<td>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 189.</td>
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<tr>
<td>SS 204</td>
<td>Physiological Psychology*</td>
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<td>Relationships between physiology, anatomy, and behavior. Physiological, anatomical, and biochemical bases for memory, learning, motivation, sleep, arousal, and stress. Prerequisite: SS 189.</td>
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<tr>
<td>SS 205</td>
<td>Comparative Psychology*</td>
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<td>Comparative studies of behavior of different species by ethological and behavioral approaches. Genetics of behavior, neuronal and hormonal controls of innate behavior, effects of early experience, generality of conditioning and learning. Prerequisite: SS 189.</td>
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<tr>
<td>SS 206</td>
<td>Human Cognition and Information Processing</td>
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<td>SS 211</td>
<td>Cultural Backgrounds of African Nations*</td>
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<td>Precolonial history and cultures of Africa. Colonialism, changing forms of political, economic, and social organization. Emergence of nationalism, Pan-Africanism, movement for independence. Contemporary sociopolitical and economic developments with case studies and student projects on selected areas.</td>
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<tr>
<td>SS 212</td>
<td>Cultural Backgrounds of Nations of Asia*</td>
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<td>Ecological and cultural areas of Asia in relation to 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 student projects on selected countries.</td>
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<tr>
<td>SS 213</td>
<td>History and Culture of Americans Called Indians</td>
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<td>Peopling of North America and cultural adaptations to its various regions. Indian relations with Spanish, French, Dutch, English, mission activity, exploration, trade, wars, Westward movements of settlers and struggles for land. Changing patterns of Indian societies. Contemporary Indian life and sociopolitical orientations — rural and urban.</td>
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ECONOMICS

SS 251 Microeconomics 3:0:3
Supply and demand analyses. Allocations of resources and distribution of income. Various market structures: perfect competition, imperfect competition, oligopoly and monopoly.

SS 252 Macroeconomics 3:0:3
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
Unemployment and inflation, urban fiscal crises, 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. Various schools of thought which anticipated and prefigured modern economic analysis. Prerequisite: SS 252 or SS 254 or equivalent.

SS 258 Comparative Economic Systems* 3:0:3
Concepts of history of economic systems: capitalism, socialism, the market and planning. Income distribution, resource allocation and modes of economic decision-making under alternative socioeconomic 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
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
Labor-management collective bargaining. Historical background, bases of power, day-to-day administration and bargaining. Intra-union bargaining, major substantive issues and problems, legislation, public policy implications, effects of technological progress, the 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 cities 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

SS 266 Libertarian Economics* 3:0:3
Libertarian, free-market analysis of economy and government policy. Contrasting 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.

SS 267 The Market for Engineers and Scientists 3:0:3
Growth of the technological professions; social implications of technological progress; applications of conventional supply-demand models; institutional forces beyond supply and demand; schooling and skills; roles of government; supply models; demand models; non-wage responses to shortages and surpluses; the method of job evaluation; earnings and employment studies; future prospects.

INTERDISCIPLINARY

SS 300-301 Guided Readings in Social Sciences 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. May be repeated for credit.

SS 310 Genes, Gender, and Society 3:0:3
Psychology, anthropology, sociology of women and men's movements. Biological bases of sex role differentiation, sex role acquisition in cross-cultural perspectives, societal allocation of roles. Women's movements—history and potential for change in current attitudes, lifestyles, the political and economic systems.

SS 356 Technology Transfer to Developing Countries 3:0:3
Mechanisms of technology transfer. Ecological, social and economic factors in technology selection and utilization. Local efforts to adapt technology to local needs. National and international means to stimulate or block technology transfer. Technology and political influence. Case studies of technology transfer to newly industrializing countries. Also listed under IE 357

SS 358 Human Resource Development in Advanced Developing Countries 3:0:3
Spectrum of technology-related human resource needs in emerging technology nations. Education of engineers, technicians and technically skilled workers. Uses of foreign personnel and foreign schools. "Brain drain" problems and their consequences. Designs of educational systems and curricula to suit national needs. Roles of technical assistance programs. Forecasting of human resource needs. May include field trip. Also listed under IE 358

Special Topics

The following special topics courses are offered from time to time by the staff of the department or visiting scholars. The specific titles and prerequisites are announced prior to registration. May be repeated for credit.

SS 361 Special Topics in Social Sciences* 3:0:3
SS 362 Special Topics in History* 3:0:3
SS 363 Special Topics in History of Science and Technology* 3:0:3
SS 364 Special Topics in Economics* 3:0:3
SS 365 Special Topics in Psychology* 3:0:3
GRADUATE COURSES

HISTORY OF SCIENCE AND TECHNOLOGY

SS 601 † History of Science and Technology: Antiquity to the Scientific Revolution 2 1/2:0:3
Biological and physical sciences from antiquity to Renaissance. Issues, aims and tools of historians of science working in these periods.

SS 602 † History of Science and Technology: Scientific Revolution to Darwin 2 1/2:0:3
Biological and physical sciences form scientific revolution to Darwin. Issues, aims and tools of historians of science working in these periods.

SS 603 † Seminar in History of Science 2 1/2:0:3
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 instructor's consent.

SS 611 † Guided Reading in History of Ideas 2 1/2:0:3
Independent studies of leading interpretive works and sources in intellectual history of Western civilization. Regular tutorial sessions and periodic study-faculty colloquia. Course may be taken twice for credit with different topical emphasis and instructors consent. Comprehensive written examination.

SS 616 † Guided Reading in History of Science 2 1/2:0:3
Independent studies of leading interpretive works and sources in history of science. Regular tutorial sessions and periodic study-faculty colloquia. Course may be taken twice for credit with different topical emphasis and instructor's consent. Comprehensive written examination.

SS 621 † History of Biology* 2 1/2:0:3
Principal issues of biologists, solutions which they have offered, and relationships between these solutions and the technical capacities both of investigators and philosophical and other "sets" inherent in milieu of investigators.

SS 622 † Development of Physical Theory from Maxwell to Einstein* 2 1/2:0:3
Origins of knowledge which eventually led to criticism of Newtonian synthesis and attempts to find suitable, more general replacement.

SS 623 † Theory and History* 2 1/2:0:3
Advanced studies of techniques and philosophies of historical writing with special reference to work of widely known historians: Burckhardt, Croce, Meinecke, Bloch, Namier, Beard, Toynebe, Hulstinga, Sarton, Pirenne.

SS 624 † History of Technology: Antiquity through Early Industrial Revolution 2 1/2:0:3
SS 625 † History of Technology: Industrial Revolution to the Present 2 1/2:0:3
These two courses involve the evolutions of techniques and tools used in man's attempts to master the environment. Reciprocal relationships between technology and other facets of society's economic and social structures, political policies; general cultural manifestations. Technological bases of historical changes 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 1/2:0:3
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 1/2:0:3
Survey of psychology against background of periods in which principal modern schools and issues emerged. Early psychology as speculative discipline, essentially part of philosophy. Differentiation of psychology into various fields. Prerequisite: SS 189-190 or equivalent or SS 135-136 or equivalent.

SS 649-650 † Environmental Studies Seminar* 3:0:0
This seminar provides an opportunity to investigate environmental issues by focusing on a specific topic each year. The aim 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. All students are responsible for a seminar paper. Guest participants on special topics. Prerequisite: SS 182 or other appropriate environment studies or instructors consent.

SS 672 † Technological Forecasting 2 1/2:0:3
Problems of technological forecasting. Morphological analysis, extrapolations of trends, heuristic and intuitive forecasts. Consideration of rational directing of technological change. Students prepare forecasts on topics of choice. Also listed under MG 672

SS 675 † Technology Transfer to Developing Countries 2 1/2:0:3
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

SS 676 † Human Resource Development in Developing Countries 2 1/2:0:3
Spectra of technology-related manpower needs in less developed countries. Education of engineers, technicians and skilled mechanics. Uses of foreign personnel, foreign schools, "brain-drain" problems. Economic consequences. Comparisons of educational systems of Western, Eastern and developing countries. Designs of curricula to suit national needs. Roles of technical assistance programs. Forecasting of human resource needs. Also listed under IE 758

SOCIAL SCIENCES

ECONOMICS

SS 700 † Industrial Organization of American Economy* 2 1/2:0:3
Monopoly and competition in America. Effects of industrial structure on business performance—profit rates, output, etc., and business behavior—collusive practices, price discriminations, 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 consent.

SS 711 † Advanced Economic Theory* 2 1/2:0:3
Advanced microtheory. 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 instructor's consent.
SS 713† Econometric Models and Methods* 2½:0:3
Econometric models with and without stochastic formulations. Supply and demand, elementary Keynesian model, consumption functions. Linear hypothesis and multiple regressions, linear models with errors in variables, time series analysis, autoregressive and distributed lag models. Simultaneous equation models. Prerequisites: SS 251 or SS 252 and MA 082 and MA 232, or equivalents.

SS 730 Mathematical Economics* 2½:0:3
Contributions of mathematical analysis to traditional economic problems. Basic mathematical tools. Capital theory, economic growth, static equilibrium, individual behavior, welfare economics. Subjects of special interest to students. Assumptions underlying (axiomatic to) models. Given these assumptions, necessary consequences deduced with some rigor.

PSYCHOLOGY

SS 906 Human Cognition and Information Processing 2½:0:3
Human cognitive capabilities including natural language and information processing. Memory, internal representation of knowledge, concept formation, symbol manipulation, language acquisition, reasoning and problem solving. Artificial intelligence approaches to natural language learning and acquisition of cognitive skills. Prerequisite: SS 189.

SS 906† Experimental Psychology I* 2½:0:3
Research designs, evaluations and treatments of experimental data. Psychophysics and scaling techniques, signal detection, simple and complex learning in both humans and animals. Prerequisite: SS 189, equivalent or instructor's consent.

SS 907† Experimental Psychology II* 2½:0:3
Methods, paradigms and procedures for laboratory and field research with human subjects, including social and environmental psychology. Students perform research in laboratory and field settings using both experimental and quasi-experimental research designs. Development of research skills for a wide variety of situations. Prerequisite: SS 906†, equivalent or instructor's consent.

SS 910† Theories of Learning* 2½:0:3
Programmed learning, behavior therapy, attitude function, and social interaction. All students are 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
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. All students are required to perform 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 and kinesthetic senses and their relations to nonsensory controlling stimuli such as states of the organism, learning, social psychological variables. Techniques for obtaining psychophysical data on each sensory system and relations of these techniques to theories of discrimination. 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
Physiological and anatomical bases of behavior. Memory, motivation, emotion, sleep reward mechanisms, psychosurgery and higher cortical functions. Prerequisite: SS 189.

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 consent.

SS 915 Behavioral and Societal Aspects of Transportation 2½:0:3
Behavioral analyses of transportation decision-making and travel characteristics. User needs in design of transportation systems; crowding, social isolation, crime, comfort and convenience, Social impacts of transport systems on communities. Prerequisite: undergraduate introductory psychology or MG 601 or equivalent. Also listed under MG 856 and TR 759

SS 920 Proseminar in Psychology 2½:0:3
Major areas of psychology required of all majors. History and systems, sensation and perception, learning, developmental and abnormal.

SS 925 Social Impact Assessment 2½:0:3
How physical changes urban or rural settings affect social systems and group and individual behavior. Measuring quality of life and social responses to technology, use of alternative futures paradigms. Students do an analysis of a problem in social impact and report findings to the class.

SS 926 Environmental Psychology 2½:0:3
Critical issues in person-environment relations, including privacy, crowding and environmental design. Work includes a term paper and a major research project, emphasizing applications of psychological research methods to practical design problems or specific environmental issues.

SS 928 Advanced Topics in Environmental Psychology 2½:0:3
This course varies from year to year depending on the needs and interests of students and instructors. Potential subjects include: social impacts of transportation systems; stress and the environment; aversive environmental factors; laboratory assessment of environmental effects on animal learning; effects of pollution; human factors of software design; assessing the built environment including the office; applied behavioral analysis.

SS 935 Engineering Projects Related to Public Administration each 3 units

SS 997 Thesis for Degree of Master of Science* each 3 units
Independent research project demonstrating scientific competence performed under guidance of advisers.

FACULTY

Pamela E. Kramer, Associate Professor of Psychology and Head of Social Sciences
B.A., Bryn Mawr College; M.Ed., M.S., Tufts University; Ph.D., Yeshiva University
Psychology of women, cognitive development, psycholinguistics and cognition.
Marvin E. Gettleman, Professor of History
B.A., City College of New York; M.A., Ph.D., Johns Hopkins University
History of the United States, American constitutional history, nationalism, modern radicalism

Helmut Gruber, Charles S. Baylis Professor of History
B.S., City College of New York; M.A., Ph.D., Columbia University
History of socialism and communism, intellectual social and cultural history of 19th and 20th centuries, contemporary history

Frederick C. Kreiling, Professor of History of Science
A.B., Hofstra College; A.M., Ph.D., New York University
History of science, environmental studies, music history

Louis Menasha, Professor of History and Administrative Officer of Social Sciences
B.A., City College of New York; M.A., Ph.D., New York University
Russian social history, revolutionary thought and politics, Soviet and contemporary history

David Mermelstein, Professor of Economics
B.A., Amherst College; Ph.D., Columbia University
Radical economics, current macroeconomic problems, comparative economic systems, urban fiscal problems

Murray N. Rothbard, Professor of Economics
A.B., M.A., Ph.D., Columbia University
Political and economic history; Austrian economics

Kurt Salzinger, Professor of Psychology
B.A., New York University; A.M., Ph.D., Columbia University
Behavior theory and learning, abnormal psychology, language behavior

Thomas B. Settle, Professor of History of Science
B.A., M.A., Ph.D., Cornell University
History of science, Galilean studies, history of biology

Felix F. Strauss, Professor Emeritus 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.E.E., City College of New York; Ph.D., New York University
Labor economics, industrial relations, economic policy

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

F. David Mulcahy, Associate Professor of Anthropology
B.A., M.A., Ph.D., University of Massachusetts
Marginal communities, human ecology, cultural symbolism, sociolinguistics

Romualdas Sviedrys, Associate Professor of History of Technology
B.A., Cornell University; Licenciada, Universidad Nacional (Colombia); Ph.D., Johns Hopkins University
Technology forecasting and technology assessment, history of technology and science since 1750, technology and science in America

Richard E. Wener, Assistant Professor of Psychology
B.A., University of Wisconsin; M.S., Ph.D., University of Illinois at Chicago
Environmental psychology, crowding, assessment of the built environment, software evaluation, clinical psychology

ADJUNCT FACULTY

Barbara Bienstock, Lecturer in Psychology, B.A., Ph.D., Queens College

Steven J. Freimark, Assistant Professor of Psychology
B.S., M.S., Polytechnic Institute of New York; M.A., Queens College; Ph.D., State University of New York at Stonybrook

Malcolm McCullough, Lecturer in Psychology
B.S., Polytechnic Institute of New York; Ph.D., Queens College

James Moore, Lecturer in History and Economics
B.A., M.A., University of Nebraska; Ph.D., State University of New York at Stony Brook
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 of modeling and simulation, 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 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. An overall grade average of B in all courses is required by the University. In addition, a B average is required in specific groups of courses, as indicated below.

Course Requirements | Units
---|---
1. Three courses from among the following:
   - EL 531 Probability
   - EL 610 Linear Systems
   - EL 611 Signals, Systems and Transforms
   - EL 613 Applied Matrix Theory
   - EL 621 Feedback Control I
   - MA 661 Statistical Inference I | 9
2. Two approved one-year sequences, which may include the above courses. At least one of these sequences must be in EL or CS courses. | 6-12
3. Approved electives | 21-15
Total | 36

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, and at least 18 units must be in EL or CS 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 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 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 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 Electrical Engineering Graduate Office.

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 adviser. Oral thesis defense and formal, bound thesis volume required. Registration of 9 units required (continuous thesis registration required). Prerequisite: degree status.

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 projects is 6-12 units by prior agreement with adviser (continuous project registration required). Prerequisite: degree status.

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). Prerequisite: passing of qualifying examination. Registration beyond 12th unit requires passing of area examination.

PARTICIPATING FACULTY

Joseph J. Bongiorno, Jr., Professor of Electrical Engineering
Norbert Hauser, Professor of Industrial Engineering and Management Science
Walter 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 and Computer Science
William R. McShane, Professor of Transportation and Industrial Engineering
Athanasios Papoulis, Professor of Electrical Engineering
Philip E. Sarachik, Professor of Electrical Engineering
Leonard G. Shaw, Professor of Electric Engineering
Martin L. Shooman, Professor of Electric Engineering and Computer Science
Joachim I. Weindling, Professor of Operations Research and System Engineering
Dante C. Youla, Institute Professor
Richard A. Haddad, Associate Professor of Electrical Engineering
Prodip Sen, Assistant Professor of Electrical Engineering
Wen Yuan Xu, Visiting Professor of Electrical Engineering

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TELECOMMUNICATIONS MANAGEMENT (NEW OFFERING)

The Management Division of Polytechnic University supported by the Electrical Engineering and Computer Science Department offers a Master of Science degree program in Telecommunications Management.

The development of the curriculum was sponsored by the New York State Center for Advanced Technology in Telecommunications (CATT) at Polytechnic University which continues to coordinate the program.

The program’s development was supported by a private sector advisory board. The board’s current functions are:

(i) monitor the effectiveness of the program
(ii) help keep the detailed course syllabi current
(iii) propose changes in the program in light of experience.

The philosophy of the program is to provide a solid foundation in telecommunications technology and management in the initial semesters of the program followed in the final year by course work integrating technology and management skills by means of case studies, exercises, and research investigations.

All students are working professionals in telecommunications and most have one or more years of managerial experience. About half the students are employed by providers of telecommunication services and the other half by users of these services.

An all-inclusive fee covers tuition and fees, text books and other educational material, special tutorials and lectures, meals on class days, use of electronic mail system and video tapes of all classes and lectures.

Admission Requirements and Application Information:

Admission to the program requires a bachelor’s degree from an accredited institution with a superior undergraduate academic record and demonstrated proficiency in calculus and statistics. Furthermore, all students must be sponsored by their employer.

Applications for admission are accepted throughout the year but admission is for Fall semester only. Because enrollment is limited, early application is recommended.

Degree Requirements:

The general requirements for the Master of Science Degree are stated elsewhere in this catalog.

Curriculum:

The curriculum consists of twelve (12) courses (36 academic units) which are offered in a structured program over a two (2) year period.

The courses in the curriculum are:

1st semester:
EL 635 Principles of Communication Networks
MG 600 Management Process
MG 650 Management of Information Systems

2nd semester:
MG 609 Managerial Accounting and Finance
MG 652 Telecommunications Regulation, Policy and Law
MG 820 Project Management

3rd semester:
EL 735 Communication Networks
MG 654 Economics of Information Systems
MG 970 Business Policy and Strategy I

4th semester:
CS 681 Information Privacy and Security
MG 607 Marketing Management
MG 971 Business Policy and Strategy II

The courses described below are unique to this program. Please refer to appropriate sections of this catalog for description of all other courses.

COURSES

MG 609 Managerial Accounting and Finance

MG 650 Management of Information Systems
The structure of information processing, information storage, information transport, and user services within organizations. Centralized versus decentralized management. The relation of distributed processing, distributed databases, and telecommunication network topology to organizational structure. The management of voice and data acquisition; benchmarking; information system contracting; pricing of information services. Operations of information systems including site planning, design and preparation; maintenance; performance monitoring; training.
MG 652 Telecommunications Regulation, Policy and Law
The relationships between the development of the telecommunications industry, national growth, and the development of telecommunications policy issues and policy making organizations. Analysis of the major issues which have impacted the telecommunications industry and commerce and society generally. The options and opportunities afforded by recent regulatory and policy issues.

MG 654 Economics of Information Systems
The concepts of market supply and demand as it applies to the market for information services and products; the rationales for, and nature of, emerging applications of information systems; the availability and pricing of services; methods of economic decision making and justification of business information systems.

FACULTY

Richard Van Slyke, Professor of Electrical Engineering and Computer Science; Director of the Center for Advanced Technology in Telecommunications. B.S., Stanford University; Ph.D., University of California at Berkeley. Computer communications; telecommunications

A. George Schilling, Professor of Management
B.E.E., City College of New York; M.S. Eng., Sc.D., Columbia University
University general management, technology management, and corporate strategy

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

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

Robert Flynn, Industry Professor of Computer Science
B.S., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Computer architecture and operating systems

Byron David, Academic Director of Management Division
B.A., Queens College of the City University of New York; M.S., Polytechnic Institute of New York
Operations Management; project management

ADJUNCT FACULTY

Anne Wells Branscomb, Adjunct Professor
B.A., Georgia College; B.A., University of North Carolina; M.A., London School of Economics; J.D., George Washington University Law School

Dennis J. Dugan, Adjunct Professor
B.S., Creighton University; Ph.D., Brown University

E. Hart Rasmussen, Adjunct Professor of Management, Director, Management Programs, Westchester. B.S., M.S., Technical University of Denmark
TRANSPORTATION

Polytechnic offers graduate degree programs in transportation and undergraduate concentrations in transportation.

The graduate degree programs lead to the degrees of:
- master of science, transportation planning and engineering
- master of science, transportation management
- engineer's degree, transportation engineering
- doctor of philosophy, transportation planning and engineering

An undergraduate degree concentration is available in the B.S. (Industrial Engineering), and electives in transportation may be chosen in other majors in consultation with the student's academic adviser.

The transportation degree programs are in the Department of Transportation and Industrial Engineering. The Department also cooperate with the Department of Civil and Environmental Engineering to provide a program in Highway Engineering as part of master's degree programs in Civil Engineering.

Students and continuing professionals from a variety of disciplines undertake studies in transportation to lead to careers in transportation planning, operations, design, or management. Some may choose to pursue this in a dual degree program which can also lead to a Master of Urban Planning or a Master of Public Administration at New York University.

For those oriented to planning or engineering careers, the Polytechnic transportation programs have a strong foundation in traffic engineering, transportation planning, and public transportation. Students may structure degree programs to build on this, emphasizing transportation infrastructure, computer aided engineering, or facility design and operations.

For those oriented to management careers, Polytechnic transportation programs have strong foundations in transportation principles, economics and finance, and transportation policy and management. Students may concentrate in public or private sector management, and emphasize transit maintenance management, logistics, or productivity management.

The primary goal of the academic program is to educate transportation planners, engineers and managers who are able to plan, functionally design and control facilities and systems which satisfy the demand for both passenger and freight transportation services.

The program stresses multi-modal approaches to transportation and maintains strong course offerings in:
- highway and traffic engineering
- public transportation
- transportation planning
- transportation safety
- freight transportation
- transportation management and economics

Students are exposed to an atmosphere that provides a meaningful integration of practical and theoretical approaches. Classroom presentations, laboratory experiences, and practical problem solutions strengthen the overall education.

DEPARTMENT REQUIREMENTS

Admission Requirements

To be eligible for admission as graduate students, applicants 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 basic skills in English adequate for the preparation of reports and papers. Such skills are evaluated in appropriate courses together with technical material. All foreign students admitted to the transportation programs are required to take an examination in English before registration. Based upon 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 is given.

Grade Requirements

To earn graduate degrees or certificates, Polytechnic requires that student have 3.0 grade point averages or better in all graduate courses and in all guided studies (readings, projects, theses, dissertations). Averages are separately computer for courses and guided studies. Transfer credits from other institutions are not included in these averages.

In addition to Polytechnic grade requirements, the transportation programs require overall averages of B or better in all required courses taken toward all degrees. Students may not repeat a course toward any of the transportation degrees more than once.

Analytic Background

All applicants for Master of Science degrees must show evidence of analytic ability, generally including two years of college mathematics and some exposure to statistics. Those not meeting the mathematics requirement fully may be admitted, but must take TR 500 (Introduction to Transportation Analysis and Computation), which is not counted for graduate work.

All applicants for certificate programs must meet the same entrance requirements as Master of Science applicants.

All applicants for the Engineer and Ph.D. degrees are expected to have a solid analytic background. They must take at least one course in graduate level statistics, regression analysis, or design of experiments as part of their studies.
Computer Literacy

There are no prerequisite requirements other than the computational requirements of TR 500. Students will be exposed, however, to uses of computers and computer packages in transportation integrated into the curricula. Emphasis is on personal computers. The Department has its own computer laboratory, using APPLE and IBM personal computers. Students also have access to Polytechnic's mainframe via the Department's terminals, and to Polytechnic's CAD/CAM system and its personal computer laboratories.

Advising

In all graduate programs, the relationship between the student and the academic adviser is important. The academic adviser assists students in selecting courses, and gives guidance in all academic matters. The academic adviser maintains checks on students' progress, and makes recommendations when problems arise. The department head assigns academic advisers.

Students should meet with their academic adviser prior to each registration, and at any other time they need advice or consultation. The student must have a detailed Program of Study formally approved by the academic adviser prior to registration. Advisers also handle requests for waivers of certain degree requirements, such as required courses. Such waivers must be approved in writing by advisers and instructors of required courses, and must be entered into students' departmental files. When such waivers are granted, students may be required to take other specific courses in their place, or to select additional electives.

Students registering for any guided studies (readings, project, thesis, dissertation) are assigned project advisers for each such activity. These are generally not the same as academic advisers, depending upon the subjects being studied. To register for guided studies, students must submit written proposals of the topics to appropriate project advisers and have academic advisers' written approval.

Doctoral students are not permitted to register for dissertation until they have passed the Ph.D. qualifying examination.

Electives

All electives require approval of the assigned academic adviser, and are identified in two groups for each degree:

**Elective Group A** Students must take at least three courses from this group, based upon electives shown in Table 1.

**Elective Group B** Remaining electives may be taken from any courses shown in Table 1, from core courses for the "other" transportation M.S. degree, or from any other courses selected by the student and the academic adviser. These may include courses at other institutions suited to individual educational needs.

A total of 36 units is required for M.S. degrees in TP & E and in TM.

Depending upon transfer credits and the particular needs and backgrounds of students, Group A requirement may be modified by the concurrence of the academic adviser and the student.

Transfer Credits

The residency requirement for M.S. degrees is 27 units, of which minimum of 27 units must be taken at Polytechnic. Students may transfer up to 9 units of acceptable courses from other institutions subject to the department's approval. Students may apply for transfer credits after they complete 12 units of appropriate graduate courses at Polytechnic. To be eligible for transfer credits, the courses
in question must be relevant to the transportation program, and students must have received B's or better. Courses graded pass-fail basis are not considered for transfer credits unless detailed course evaluations from the instructors are provided. All transfer requests must be accompanied by an official transcript from transferring institutions. Transfer credits not included in computing grade point average. Validation credits by examination may not be used for any transportation degrees.

**DUAL DEGREE PROGRAM WITH NYU**

The transportation program at the Polytechnic has a dual degree program with the Graduate School of Public Administration at New York University. Students may pursue an M.S. (transportation planning and engineering) or an M.S. (transportation management) at Polytechnic, and a Master of Urban Planning (MUP) or a Master of Public Administration (MPA) at NYU. Because of course waivers or advanced standing where appropriate, the two degrees may be obtained with some efficiencies in total units of study and in total time for two distinct degrees.

**ELECTIVES FOR THE TRANSPORTATION M.S. DEGREES**

<table>
<thead>
<tr>
<th>TRANSPORTATION FACILITY DESIGN AND OPERATION</th>
<th>ELECTIVE GROUP A</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR 660 Urban Public Transportation</td>
<td>X X</td>
</tr>
<tr>
<td>TR 670 Planning and Design of Terminals</td>
<td>X</td>
</tr>
<tr>
<td>TR 704 Highway Capacity and Traffic Analysis</td>
<td>X</td>
</tr>
<tr>
<td>TR 705 Advanced Topics in Highway Capacity and Traffic Analysis</td>
<td>X</td>
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<tr>
<td>TR 710 Design of Traffic Facilities</td>
<td>X</td>
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</tbody>
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<thead>
<tr>
<th>TRANSPORTATION PLANNING AND URBAN PLANNING</th>
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<tr>
<td>TR 602 Urban Transportation Planning</td>
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<tr>
<td>TR 603 Computer Applications and Analytic Techniques in Transportation</td>
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<tr>
<td>TR 630 Urban Planning Principles</td>
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<tr>
<td>TR 633 Land Use and Environmental Planning</td>
</tr>
<tr>
<td>TR 715 Urban Goods Movement</td>
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<tr>
<th>TRAFFIC SAFETY</th>
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<tbody>
<tr>
<td>TR 864 Transportation Safety Engineering</td>
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<tr>
<td>TR 865 Traffic Safety Engineering</td>
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**TRANSPORTATION MANAGEMENT: PRIVATE AND PUBLIC SECTORS**

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<thead>
<tr>
<th>TRANSPORTATION MANAGEMENT: PRIVATE AND PUBLIC SECTORS</th>
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<tbody>
<tr>
<td>TR 753 Management of Transportation and Distribution Operations</td>
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<tr>
<td>TR 754 Logistics Analysis</td>
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<tr>
<td>TR 760 Management of Transit Maintenance and Operations</td>
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<tr>
<td>IE 620 Project Planning and Control</td>
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<tr>
<td>IE 645 Productivity Management</td>
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<tr>
<td>MG 601 Organizational Behavior</td>
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<tr>
<td>MG 613 Industrial Relations</td>
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<tr>
<td>MG 614 Collective Bargaining</td>
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</tbody>
</table>

Note: The "X" denotes a Group A Elective for the indicated program.

The two institutions also have an option in which students registered in any of the cited degree programs may take one or more courses from the pool of courses offered by the two cooperating institutions. Such registration is subject to prior approval by the academic adviser for the specific degree program in which students are enrolled.

Those interested in the Dual Degree Program must apply to that program specifically, by indicating this in a letter to the Polytechnic Transportation Program or to the NYU Graduate School of Public Administration, accompanied by application forms to both institutions. To aid in program planning, students are encouraged to apply initially, rather than to convert later to the Dual Degree Programs. Those already enrolled in one of the degrees cited, and interested in the Dual Degree Program, should consult their academic advisers.

**REQUIREMENTS FOR THE ENGINEER DEGREE IN TRANSPORTATION ENGINEERING**

Engineer degrees in transportation engineering are intended to be terminal degrees for those students wishing advanced practical education beyond the M.S. level. It requires 36 units beyond the M.S. (Transportation Planning and Engineering).

Engineer degree programs require all of the following prerequisites for admission:

1. An undergraduate degree in an engineering discipline from an accredited institution;

2. All required courses for the master of science in transportation planning and engineering, or their equivalent;

3. A master of science in transportation planning and engineering, or equivalent.

Students lacking any of these must fulfill the prerequisites in addition to the degree requirements listed below. Studies for Engineer's Degrees must include at least one graduate-level course in statistics, regression analysis, or design of experiments.
All students must complete the following courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course 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 Traffic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>TR 998</td>
<td>Engineering Project in Transportation</td>
<td>6</td>
</tr>
</tbody>
</table>

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 and choose an additional 6 units approved by the academic advisers.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>TR 603</td>
<td>Computer Applications and Analytic Techniques in Transportation</td>
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<tr>
<td>TR 660</td>
<td>Urban Public Transportation</td>
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<tr>
<td>TR 665</td>
<td>Design of Rail Facilities</td>
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<tr>
<td>TR 670</td>
<td>Planning and Design of Terminals</td>
</tr>
<tr>
<td>TR 671</td>
<td>Airport Planning and Design</td>
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<tr>
<td>TR 672</td>
<td>Port Planning and Design</td>
</tr>
<tr>
<td>TR 705</td>
<td>Advanced Topics in Highway Capacity and Traffic Analysis</td>
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<tr>
<td>TR 710</td>
<td>Design of Traffic Facilities</td>
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<tr>
<td>TR 715</td>
<td>Urban Goods Movement</td>
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<tr>
<td>TR 720</td>
<td>Flexible Pavements: Design and Evaluation</td>
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<tr>
<td>TR 721</td>
<td>Rigid Pavements: Design and Evaluation</td>
</tr>
<tr>
<td>TR 865</td>
<td>Traffic Safety Engineering</td>
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</tbody>
</table>

Central Electives 18
Additional Electives 6
Total beyond M.S. 36

If any courses listed above are taken as part of a prior M.S. program, additional electives are added to achieve the required total of 36 units beyond the M.S. degree. All 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 credits may be awarded toward this degree.

**DOCTOR OF PHILOSOPHY DEGREE IN TRANSPORTATION PLANNING AND ENGINEERING**

The Ph.D. in transportation planning and engineering required 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 including all courses required for the M.S. degree.
2. Two 15-unit minors in related areas, one of which is generally in quantitative methods. The second often focuses on a specific transportation area, such as transportation facility design, transportation management, or transportation infrastructure. The minors should support the dissertation topic.
3. A 30-unit dissertation, which must be an original piece of research which meaningfully advances 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 courses to support their dissertation development and to aid completion of the Ph.D. qualifying examination. Applicants to the Ph.D. program are urged to make appointments with Ph.D. program academic advisers for individual consultations and recommendations.

Before being permitted to register for dissertation units, candidates must pass a comprehensive Ph.D. qualifying examination. Given once a year, usually in June, it consists of several written and oral portions. Copies of previous examinations are available on request from the Department Office to aid the students in preparation for this examination.

Students normally take the qualifying examination after their first year of full-time coursework (or their part-time equivalent) is completed. All students who wish to take the examination are permitted to do so once they have discussed their interest with the academic adviser. Subsequent attempts are at the discretion of the Department; in no case are more than three attempts permitted.

Ph.D. candidates must also qualify in a foreign language, which entails translation of a part of a technical book or article with the aid of a dictionary. Students whose native language is not English may qualify in English if there is a body of related technical knowledge in their primary language.

The residency requirement for the Ph.D. is 30 units, which must include the dissertation. Candidates are, thus, only required to complete their dissertations at Polytechnic to earn degrees here. Any and all graduate courses taken at other approved institutions which are appropriate for either majors or minors may be transferred, provided they are of graduate level and that grades of B or better were 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 often include faculty members from other departments.

Once students register for dissertation units, they must meet several requirements. Dissertation registration must be continuous (excluding summers) until work is completed. Leaves of absence must be formally requested from the Graduate Office. Student must submit and orally defend dissertation proposals before registering for a second full-time semester of dissertation work, or before going beyond 9 units of combined full-time/part-time dissertation study. At the end of each semester of registration, students must submit written progress reports to their dissertation advisers. Upon completion, dissertations must be presented and orally defended before the faculty.

**CERTIFICATE PROGRAMS**

The Department offers graduate certificates to students completing 15 units in concentrated subareas of transportation planning, engineering, or management. Certificate
programs are geared to students who do not wish to commit themselves to full advanced degree programs. These may be students with bachelor's degrees who wish to specialize in other aspects of transportation, or those already holding advanced degrees who wish to develop additional specialties and receive formal certification for it. Students who enroll in certificate programs may apply for transfer to degree programs without loss of credits, assuming they are admitted to degree studies and that the courses taken are appropriate to the degree.

The Transportation Program offers the following certificates:

**Traffic Engineering Certificate**
- **TR 701** Traffic Engineering 15
- **TR 704** Highway Capacity and Traffic Analysis
- **Plus three of:**
  - TR 670 Planning and Design of Terminals
  - TR 705 Advanced Topics in Highway Capacity and Traffic Analysis
  - TR 710 Design of Traffic Facilities
  - TR 865 Traffic Safety Engineering

**Transportation Planning Certificate**
- **TR 600** Characteristics of Transportation Demands and Systems
- **TR 601** Travel Demand Forecasting
- **TR 602** Urban Transportation Planning
- **TR 701** Traffic Engineering
- **Plus one of:**
  - TR 603 Computer Applications and Analytic Techniques in Transportation
  - TR 630 Urban Planning Principles

**Transportation Facility Design and Operation Certificate**
- **TR 670** Planning and Design of Terminals
- **TR 701** Traffic Engineering
- **TR 710** Design of Traffic Facilities
- **Plus two of:**
  - TR 660 Urban Public Transportation
  - TR 665 Design of Rail Facilities
  - TR 671 Aircraft Planning and Design
  - TR 672 Port Planning and Design
  - TR 720 Flexible Pavements: Design and Evaluation
  - TR 721 Rigid Pavements: Design and Evaluation

**Public Transportation Certificate**
- **TR 660** Urban Public Transportation
- **TR 759** Transportation Policy and Decision Making
- **TR 760** Management of Transit Maintenance and Operations
- **Plus two of:**
  - TR 600 Characteristics of Transportation Demands and Systems

**Transportation Management and Economics Certificate**
- **TR 750** Transportation Economics and Finance
- **TR 755** Legal and Regulatory Aspects of Transportation
- **TR 758** Transportation Management and Decision Making
- **TR 759** Transportation Policy and Decision Making
- **Plus one of:**
  - TR 760 Management of Transit Maintenance and Operations
  - TR 754 Logistics Analysis
  - MG 613 Industrial Relations
  - MG 614 Collective Bargaining

Units earned toward certificate programs are transferable to degree programs if applicable. No course, however, may be credited toward more than one certificate program.

**UNDERGRADUATE COURSES**

The Department offers several undergraduate courses, which may be used in transportation concentrations (such as in the B.S. (I.E.) degree), as technical electives where approved by advisers, or as free electives. Students with suitable undergraduate records may also take graduate transportation courses in their senior year, if approved by their advisers. Graduate students may not take undergraduate courses for credit.

There are three courses with TR numbers, and one course with an IE number. In addition, the Transportation Program faculty staffs the undergraduate Civil Engineering course in Highway Engineering.

**IE 350 Logistics**
3:0:3
Analysis of logistic problems and procedures applied to inventory control, materials handling systems, packaging, warehousing, transportation, facility location, information/communications, and customer services. Cost tradeoffs between the various components in optimization of the total logistics system. Logistics system designs and productivity measures in business and military cases and applications. Prerequisite: IE 328.

**TR 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.

**TR 360 Traffic Planning and Operations**
3:0:3
Development and use of traffic engineering techniques to aid in planning, functional design and control of highway and street systems. Traffic studies, accident analysis, capacity analysis, sign and coordination, etc. Practical applications. Prerequisite: junior status.
TR 361 Transportation Demand Models 3:0:3

TR 362 Public Transportation 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, rail rapid transit, demand actuated transit, etc. Operational and planning aspects: scheduling, fare, structure and fare collection systems. Prerequisite: junior status.

GRADUATE COURSES

Refer to Table 1 for identification of elective courses by specialty area. These groupings are intended to aid students in course selection, subject to approval of academic advisers.

TR 500 Introduction to Transportation Analysis and Computations 2:1:3
Review of computational methods. Probability and statistics applications to transportation problems. Sampling and forecasting for transportation planning. Introduction to personal computer applications, and mainframe package use. Group projects performed in laboratory setting. (No graduate credit toward any transportation degree.)

TR 600 Characteristics of Transportation Demand and Systems 2:4:0:3
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 theory and methods of forecasting urban activities.

TR 601 Travel Demand Forecasting 2:4:0:3
Theory and application of travel forecasting methods to predict the amount and nature of travel on transportation systems. Corequisite: TR 600 or equivalent. Also listed under CE 804.

TR 602 Urban Transportation Planning 2:4:0:3
Transportation system planning from regional to local scales. Problem identification, issues and needs. Planning, design and operation of transportation systems. Evaluation of transportation system performance and impact. Prerequisite: TR 601 or equivalent.

TR 603 Computer Applications and Analytical Techniques in Transportation 2:6:0:3
Model-building in transportation by use of analytic techniques and computer tools such as spreadsheets, statistical analysis, and existing transportation and traffic engineering packages. Emphasis in computer applications is on personal computers and existing software packages. Analytic techniques are addressed on three levels: (1) basic concepts; (2) case studies; and (3) review of literature. Modeling of trip generation, transportation safety, and other topics by deterministic analysis. Sensitivity analysis. Cost-utility analysis. Surveys and errors in surveys. Transportation packages including NETSIM, TRANSYT, TRAF, and Assignment packages. Prerequisites: TR 701 and TR 600.

TR 629 Transportation Workshop 0:5:3
Comprehensive projects designed to assure students' understanding of basic principles and their applications, depending on knowledge from the M.S. requirements. Typically, two to four design or evaluation projects are completed, some of which are group projects. Written reports and oral presentations required. Projects or sub-assignments are based upon the degree the student is pursuing. Prerequisites for M.S. (TP & E) students: TR 601 and TR 701. Pre- or co-requisites for M.S. (TM) students: TR 758 and TR 751.

TR 630 Urban Planning Principles 2:4:0:3
A survey of the contemporary theory and methods of the planning function. Also listed under CE 810.

TR 633 Land Use and Environmental Planning 2:4:0:3
Land use planning and its interactions with transportation planning processes; relationships between land use patterns and travel demands; objectives and methods of land use planning; zoning and other implementation measures. Prerequisite: TR 630 or adviser's approval.

TR 665 Design of Rail Facilities 2:4:0:3

TR 670 Planning and Design of Terminals 2:4:0:3
Passenger and freight terminals, with emphasis on system descriptions of these facilities. Land, marine, and air terminals. Methods for determining levels of service for pedestrian flow, TOFC and truck terminals are also covered. Also listed under CE 840.

TR 671 Airport Planning and Design 2:4:0:3
Techniques for forecasting air passenger traffic and aircraft operations at commercial and general aviation facilities. Principles and practices for planning and design of terminal facilities, ground transportation systems, parking facilities, runways and navigation aids. Airport site selections, configuration and economics. Also listed under CE 841.

TR 672 Port Planning and Design 2:4:0:3

TR 701 Traffic Engineering 1:3:3
Traffic engineering and its role in person movement. Traffic demand and its generation and management. Capacity analysis concepts and basic study techniques. Substantial treatment of intersections, arterials, and arterial management. Laboratory emphasis on field procedures and on the use of analysis procedures, including personal computer applications. Also listed under CE 805.

TR 704 Highway Capacity and Traffic Analysis 1:3:3
TRANSPORTATION

TR 705 Advanced Topics in Highway Capacity and Traffic Analysis 2½:0:3
Basic research collection and use of traffic data. The importance of microscopic parameters and their use is emphasized. Calibration of highway capacity analysis techniques for uninterrupted flow, signalized intersections, and other facilities. Analysis of traffic breakdown and recovery characteristics. Coordination of various study techniques to analyze development impacts and related problems. Prerequisites: TR 701 and TR 704 or instructor's permission.

TR 710 Design of Traffic Facilities 2½:0:3
Functional and preliminary design principles and analyses for freeways and arterials. Interpretation 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 2½:0:3
Urban goods movement, primarily by truck, and its effect on urban mobility. 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.

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, including Marshall, Hubbard-Field and Hveem stability tests. Viscosity of capillary viscometer. 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 highway and airport pavements. Pavement performance and evaluation. Laboratory tests of plain and reinforced concrete pavements. Nondestructive testing techniques. Prerequisites: CE 351 and CE 252 or equivalent. Also listed under CE 802

TR 750 Transportation Economics and Finance 2½:0:3

TR 751 Transportation Financial Control 2½:0:3
Analysis of financial performance and needs of private and public transportation companies and agencies. Balance sheet and income statement derived measures are used for comparative financial studies among various private modes. Financial needs of public transportation. Federal programs, state/local subsidies and dedicated taxes.

TR 753 Management of Transportation and Distribution Operations 2½:0:3
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; analyses of logistics costs and uses of logistic system models.

TR 754 Logistics Analysis 2½:0:3
Basic principles of logistics costs and analysis; interactions to physical distribution aspects of the shipper (packaging, plant and warehouse location) and related logistical analysis approaches.

TR 755 Legal and Regulatory Aspects of Transportation 2½:0:3
Origins, causes and effects of regulation on transportation and society in the United States economic and constitutional basis for transportation regulation. Legal basis, structure and function of federal, state and local regulatory bodies and their interaction with transportation industries. Current controversies concerning deregulation of sectors of the transportation industry.

TR 758 Transportation Management and Decision-Making 2½:0:3
Current multi-dimensional problems in financial management, organizational management, labor-management relations, ridership development and productivity which challenge top managers in the mass transportation and railroad industries. Case studies are used exclusively.

TR 759 Transportation Policy and Decision-Making 2½:0:3
Analysis of the major policies, regulations, and controls established or imposed by government at all levels—federal, state, and local—which currently impact on the transportation industry. (All modes considered). Case studies used exclusively.

TR 760 Management of Transit Maintenance and Operations 2½:0:3
Management of functional transit system aspects, including design and monitoring of maintenance functions to provide viable operating fleets and right-of-way, and management of daily operations, including scheduling, dispatching, and street management.

TR 860-861 Selected Topics in Transportation I, II each 2½:0:3
Periodic presentations of topical materials of current interest. Recent topics presented are: decision-making in transportation; computer packages in transportation; transportation safety. Some have been added to regular curricula because of their popularity here. Prerequisites: academic adviser's approval.

TR 864 Transportation Safety Engineering 2½:0:3
Application of engineering principles to the operator-vehicle-environment system in all transportation modes to achieve maximum levels of human safety (both accident occurrence and death/injury reduction). Proven practical engineering approaches in each mode and pan-modally are applied in the removal of hazards and hazardous conditions at every stage of transport activities, including planning, design, engineering, operation and maintenance.

TR 865 Traffic Safety Engineering 2½:0:3
Applications of system-safety engineering principles to the driver-vehicle-environment system to achieve higher levels of human safety (reduced accident occurrence and reduced severities of injuries). Proven, practical approaches are applied in the removal of hazards and hazardous conditions in every stage of the highway system activity cycle, including planning, design, engineering, operation and maintenance.  

TR 888 Special Topics in Transportation for Developing Nations 2½:0:3
Possible topical issues include: transportation planning for economic development, financing international transportation projects, design and construction of low-type roadways, management of multinational project efforts.

TR 901-902 Readings in Transportation I, II 2½:0:3
Special problems in transportation under the direct supervision of faculty members. Prerequisite: academic advisers' approval.

TR 951-952 Transportation Seminar I, II 2½:0:3
Relevant topics in transportation by guest speakers. Presentations and discussions of ongoing research by course participants and faculty. Required of all full-time degree students in the program. Prerequisite: academic advisers' approval.
TR 962 Master's Project in Transportation Planning and Engineering each 3 units
An independent project leading to a comprehensive report demonstrating professional competence. Projects must be orally defended and be submitted in (unbound) written form. Prerequisites: degree status and academic advisers' approval.

TR 983 Master's Internship in Transportation each 3 units
Internships with relevant transportation organizations, leading to report demonstrating students' professional competence. Students are examined orally and must be orally defended and be submitted in (unbound) written form. Prerequisites: degree status and academic advisers' approval.

TR 966 Master's Project in Transportation Management each 3 units
An independent project leading to comprehensive report demonstrating professional competence. Projects must be orally defended and be submitted in (unbound) written form. Prerequisites: degree status and academic advisers' approval.

TR 997 Thesis for the Degree of Master of Science each 3 units
Continuation of project work, initiated in TR 962, or original research of sufficient comprehensiveness for motivated students. Bound written report required. Prerequisite: degree status and academic advisers' 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 academic adviser'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 worthy of publication in recognized scientific or engineering journals. Students are required to take an oral examination of the subject of the dissertation and related topics. Prerequisites: degree status, passage of Ph.D. qualifying examination and academic adviser's approval.

TRANSPORTATION TRAINING AND RESEARCH CENTER

The Polytechnic established the Transportation Training and Research Center (TTRC) in 1975 to focus its research and non-degree training related to transportation. The Center has encouraged such research and has involved faculty from a number of the Polytechnic's departments and programs in research proposals and projects. In recent years, prospective principal investigators have come from transportation, industrial engineering, mechanical and aerospace engineering, electrical engineering, civil engineering, metallurgy, and social sciences.

Students are encouraged to become involved in the Center's research as research fellows, research associates, and project aides. In some cases, the student's education is fully funded by research.

Recent projects within the Center have included the development of the 1985 edition of the Highway Capacity Manual and the related personal computer software development; demand estimation for a high-speed ferry system; trip generation estimation, tire-pavement noise investigations; evaluation of single cable communications in rail rapid transit and policy studies on van-pooling, express buses, and local bus-routing. Training development work has covered highway capacity, transit management for middle managers, transit management for first line supervisors, and microcomputer applications.

The Center anticipates a continuing emphasis on its strengths in traffic and highway engineering, transportation planning, and transportation management, as well as stronger emphasis in infrastructure, computer aided engineering, telecommunications related to transportation, and freight and goods movement.

FACULTY

William R. McShane, P.E., Professor of Transportation and Industrial Engineering; Head, Department of Transportation and Industrial Engineering; Director, Transportation Training and Research Center.
B.E.E., Manhattan College; M.S., Ph.D., Polytechnic Institute of Brooklyn
Traffic engineering, highway capacity, expert systems in transportation, PC applications and models, economics and finance

Edmund J. Cantilli, P.E., Professor of Transportation and Safety Engineering
B.A., B.S.C.E., Columbia University; Certificate in Highway Traffic Engineering, Yale University; Ph.D., Polytechnic Institute of Brooklyn
Traffic engineering, highway capacity, expert systems in transportation, PC applications and models, economics and finance

John C. Falcochio, P.E., Professor of Transportation Engineering; Academic Officer, Transportation
B.S.E., M.S., Ph.D., Polytechnic Institute of Brooklyn; Certificate in Highway Traffic Engineering, Yale University.
Transportation planning; public transportation; travel demand; traffic engineering; transportation system evaluation; transportation systems management

Walter Helly, Professor of Operations Research
B.S., Cornell University; M.S., University of Illinois; Ph.D., Massachusetts Institute of Technology.
Queues and routing in networks; land use models; stochastic mode choice models

Herbert S. Levinson, P.E., Visiting Professor of Transportation
B.S.E., Illinois Institute of Technology; Certificate in Highway Traffic Engineering, Yale University
Transit operations, traffic engineering and capacity, highway engineering, transportation policy

Roger P. Roess, Professor of Transportation Engineering and Dean of Engineering
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn
Traffic capacity and design; traffic engineering; public transportation; transportation economics
TRANSPORTATION

Philip A. Habib, P.E., Associate Professor of Transportation Engineering
B.E., City College of New York; M.S., Ph.D., Polytechnic Institute of Brooklyn
Goods movement; highway design; highway planning; transportation planning; terminal planning; traffic engineering

Ravinder Nanda, Associate Professor of Industrial Engineering and Operations Research
B.S., Banaras Hindu University (India); M.S., Ph.D., University of Illinois
Operational planning of production systems; productivity measurement and evaluation; work design and performance improvement; training of management and supervisory personnel

ASSOCIATED FACULTY

Luiz Gomes, Visiting Professor (1985); Professor, Catholic University of Rio de Janeiro (Brazil)

ADJUNCT FACULTY

Walter H. Kraft, Adjunct Professor
B.S., M.S., Newark College of Engineering; Dr. Eng. Sc., New Jersey Institute of Technology

Albert T. Rosselli, Adjunct Professor
B.C.E., City College of New York

Edmund Chalom, Lecturer
B.S.E.E., University of Maryland; M.B.A., Long Island University; M.S., Polytechnic Institute of New York

Gennaro E. Sansone, Lecturer
B.S.E.E., Kansas State University; M.B.A., Iona College

TRANSPORTATION ADVISORY COMMITTEE

Polytechnic has a Presidential Transportation Advisory Committee which aids Polytechnic and its Transportation Programs in long-range strategic planning related to transportation. The committee is composed of distinguished transportation professionals and policymakers.

The members as of January, 1986, are as follows:

S.S. Greenfield, Chairman of the Committee
Parsons Brinckerhoff, Chairman of the Board
Samuel Schwartz
First Deputy Commissioner of Transportation, NYC Department of Transportation
New York City

Donald S. Berry,
Professor Emeritus,
Northwestern University

Louis J. Gambaccini,
Assistant Executive Director and Director of Administration of the Port Authority of New York and New Jersey

David Gunn
President, New York City Transit Authority

Paul Soros
President, Soros Associates
THE CORPORATION

Richard Laster, President and Chief Executive Officer, DNA Plant Technology Corporation

Stephen L. Levy, Executive Vice President and General Manager, Japanese Operations, Motorola, Inc.

Eugene H. Luntz, Chancellor, Long Island University

Hans Mark, Chancellor, University of Texas System

John S. Mayo, Executive Vice President, AT & T Bell Laboratories

Joseph Newman, President, Tishman Research

Stanley M. Nisenson, District Manager, NYNEX

Donald D. Pascal, Retired Director, National Starch & Chemical Corporation

Robert S. Rubin, Financial Consultant

Robert J. Sanator, President, Geotel, Inc.

Geoffrey R. Simmonds, Chairman of the Board, Hercules Aerospace Company

Henry J. Singer, Vice President & General Manager, University & Industrial Sales Division, General Electric Company

Harrison V. Smith, Director, Train Smith Counsel

Paul Soros, President, Soros Associates International, Inc.

Charles Strang, Chairman and Chief Executive Officer, Outboard Marine Corporation

Jerry M. Sudarsky, President, JMS Associates

Harry C. Wechsler, President, Farboil Company

David Westerman, Esq., J. Forrestal Industry Professor, Defense Systems Management College

George L. Wilcox, Retired Director and Vice Chairman, Westinghouse Electric Corporation

Sidney G. Albert, Retired President, Albert Pipe Supply Company

Preston R. Bassett, Retired President, Sperry Gyroscope Company

George F. Habach, Management Consultant

William L. Lestner, Chairman of the Board and Chief Executive Officer, Fairmount Chemical Company

Herman F. Mark, Dean Emeritus, Polytechnic University

William F. May, President, Statue of Liberty/Ellis Island Foundation, Inc.


Ernest Weber, President Emeritus, Polytechnic University

HONORARY TRUSTEES

Bern Dibner, Bundy Library

Gregory Halpern, Chairman of the Board, Universal High Technologies

Koji Kobayashi, Chairman of the Board and Chief Executive Officer, NEC Corporation

ADVISORY TRUSTEES

Harry W. Buchanan, Vice President, Celanese, Inc.

Vincent A. Calarco, President and Chief Executive Officer, Crompton & Knowles Corporation

Harmon F. Hoffmann, Senior Executive Vice President and Chief Operating Officer, Transportation Group, Ryder Systems, Inc.

Louis H. Pigni, President, Fairchild Weston Systems, Inc.

Leonard F. C. Reichle, Executive Vice President, Ebasco Services, Inc.
THE ADMINISTRATION

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