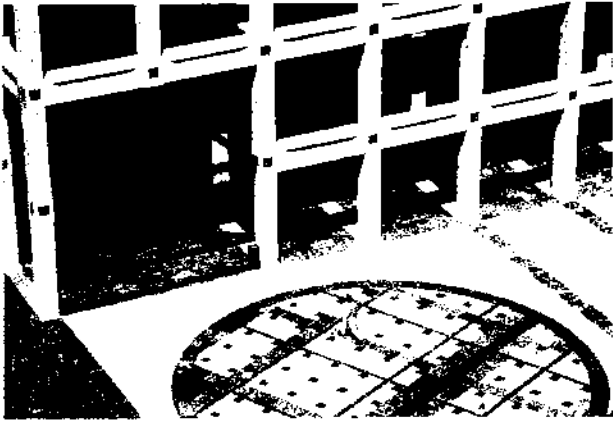


# **Polytechnic** UNIVERSITY

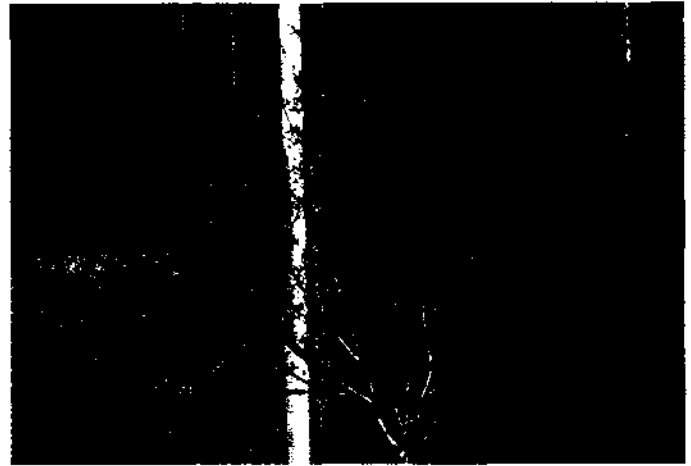
## **CATALOG** **1993-1995**

**Brooklyn • Long Island • Westchester**



**Brooklyn Campus**  
Six MetroTech Center  
Brooklyn, New York 11201  
(718) 260-3600

**Long Island Campus**  
Route 110  
Farmingdale, New York 11735  
(516) 755-4400



**Westchester Graduate Center**  
36 Saw Mill River Road  
Hawthorne, New York 10532  
(914) 347-6940

**Polytechnic University is an internationally renowned institution dedicated to the advancement and application of the science and engineering of technology. It is the leading technological university in the New York City metropolitan region. Its mission is to provide undergraduate and graduate education in engineering, the sciences, mathematics, management, and the liberal arts, and to conduct state-of-the-art basic and experimental research to advance technology, management of technology and the relationships between social institutions and technology. Through excellent teaching and research programs, Polytechnic's goal is to play a positive role in the improvement of society in general, particularly as it relates to the development and application of technology.**

# CONTENTS

## **PART I—GENERAL AND INSTITUTIONAL INFORMATION .....5**

Administrative Offices .....	6
Academic Calendar .....	7
Polytechnic University Profile .....	9
Academic Programs and Policies .....	15
Campus Life and Supporting Services .....	22
Admissions .....	28
Financial Aid .....	32
Registration .....	40
Tuition & Fees .....	41
Placement Statistics .....	43
Statistics on Enrollment and the Student Body .....	44

## **PART II—ACADEMIC PROGRAMS, DEGREE REQUIREMENTS AND CURRICULA .....45**

Degrees Offered at Polytechnic .....	47
University Degree Requirements .....	48
A Brief Guide to Course Descriptions .....	55
Aerospace Engineering .....	56
Chemical Engineering .....	62
Chemistry .....	68
Civil Engineering .....	76
Computer Engineering .....	94
Computer Science .....	100
Electrical Engineering .....	113
Electrophysics .....	137
Environmental Engineering and Environmental Health Science .....	139
Humanities and Communications .....	150
Industrial Engineering .....	160
Information Systems Engineering .....	165
Management .....	167
Management of Technology .....	175
Manufacturing Engineering .....	177

Materials Science and Engineering (Metallurgy) .....	182
Mathematics and Statistics .....	187
Mechanical Engineering .....	195
Operations Management .....	206
Physics .....	207
Polymer Science and Engineering .....	216
Social Sciences .....	219
Systems Engineering .....	227
Telecommunications and Computing Management .....	229
Transportation .....	231

## **PART III—SPECIAL PROGRAMS .....238**

Academic Honor Students .....	239
Cooperative Education Program .....	240
Higher Education Opportunity Program (HEOP) .....	242
Military Science .....	244
Physical Education and Athletics .....	247
The YES Center .....	248

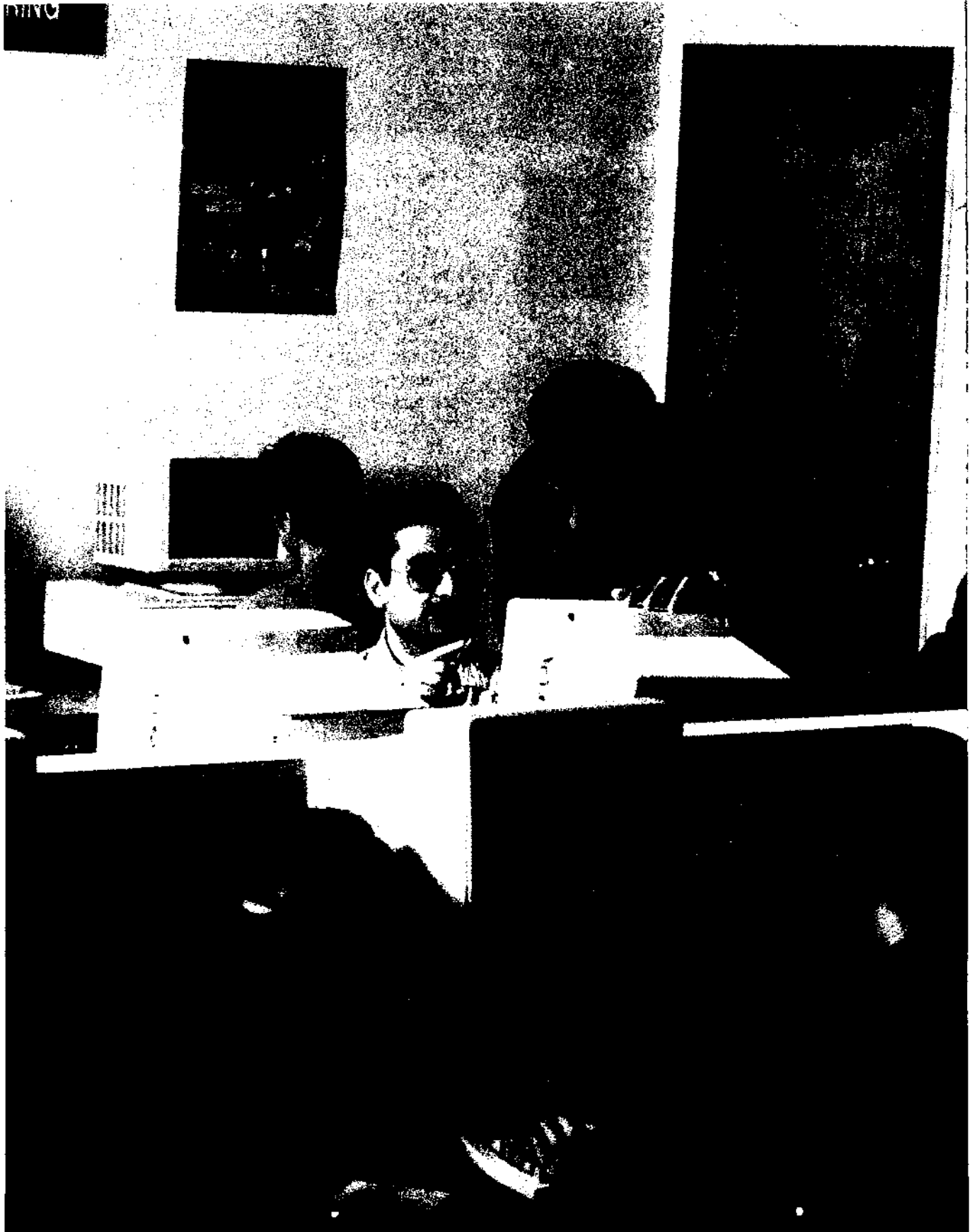
## **PART IV .....250**

The Corporation .....	251
The Administration .....	252
The Faculty .....	254

## **INDEX .....258**

## **THE ROUTES TO POLYTECHNIC .....260**

NYC



# PART I

## GENERAL AND INSTITUTIONAL INFORMATION



The Polytechnic University Catalog is an official publication of the University. The catalog provides information about academic programs and is intended to provide a helpful summary of University policies and procedures, and selected activities and services. Information concerning admission, academic regulations and requirements, student services, academic offerings, and a listing of the administrative officers and faculty are included. Every effort has been made to publish a catalog that is as complete and as accurate as possible, but requirements, deadlines, tuition, fees, curricula, courses, and staffing are subject to change at any time without advance notice or obligation. This catalog was prepared well in advance of its effective date; therefore some course descriptions may vary from actual course content due to advancements in the discipline, interests of individual instructors, or decisions of the faculty to change the scope and/or content of the course. Supplements to this catalog in the form of schedules of classes are issued for each semester and for summer sessions. Those schedules include updated information about course offerings, tuition, fees, registration, and academic procedures.

# ADMINISTRATIVE OFFICES

Polytechnic University has three campus centers:

- The Brooklyn Center with administrative offices in the Jacobs Building, is located at 6 Metrotech Center, Brooklyn, NY.
- The Long Island Center is on Route 110 in Farmingdale, NY.
- The Westchester Center is at 36 Saw Mill River Road, Hawthorne, NY.

## ADMISSIONS

### Undergraduate Admissions:

Brooklyn Center - Rm. 158, Jacobs Bldg. (718) 260-3100

Long Island Center - Rm. 118, Administration Building (516) 755-4200

### Graduate Admissions:

All Centers (718) 260-3200

Interviews are scheduled by appointment, Monday through Friday, 9AM-5PM. Call the admissions office for appointment and information.

## CAREER SERVICES

For assistance in finding part-time, full-time and summer positions and for advice on careers, Monday through Friday, 9AM-5PM, 3rd floor, Nichols Building. (718) 260-3650.

Long Island Center, (516) 755-4270.

## COOPERATIVE EDUCATION

For consultation on this earning and learning program, Monday through Friday, 9 AM to 5 PM, 3rd floor, Nichols Building; Telephone (718) 260-3650. Long Island Center Grumman Hall (516) 755-4270.

## FINANCIAL AID

For information on tuition and all matters relating to financial aid and scholarships: Brooklyn Center - Room 158, Jacobs Building, Monday through Friday, 9AM-5PM, Telephone (718) 260-3300.

Long Island Center, Admissions and Financial Aid Office, Room 118, Monday through Friday, 9AM-5PM, Telephone (516) 755-4345.

## LONG ISLAND CENTER

For information concerning programs offered on Long Island, Monday through Friday, 9AM-5PM, (516) 755-4200.

## REGISTRAR

For registration and other record-related information:

Monday and Thursday, 9AM-6PM (during semester); 9AM-5PM when classes are not in session.

Tuesday and Wednesday, 9AM-5PM, and Friday, 9AM-3PM, Room JB359, Telephone (718) 260-3900.

Long Island Center, Room 121, (516) 755-4450.

## STUDENT ACCOUNTS/BURSAR

For payment of bills and information, Brooklyn Office hours are Monday and Thursday, 9AM-6PM; Tuesday and Wednesday, 9AM-5PM, Friday, 9AM-2PM, Room JB256, 2nd floor, (718) 260-3700.

Long Island Office hours are Monday and Thursday, 10:30AM - 6:00PM, Tuesday and Wednesday 10:00AM - 4PM and Friday, 10:30AM - 2:30PM, (516) 755-4225. Hours at both campuses are extended during registration.

## STUDENT LIFE

For counseling, guidance, problem resolution, housing, co-curricular activities, new student programs, health insurance, academic and disciplinary policy administration, and related matters:

Brooklyn:

Monday-Thursday, 9AM-5PM  
Friday, 9AM-2PM  
(718) 260-3800

Farmingdale:

Monday-Friday, 9AM-5PM  
(516) 755-4325

## WESTCHESTER CENTER

For information concerning graduate programs offered in Westchester, Monday through Friday, 9:00AM - 5:30PM, (914) 347-6940. All office services are provided through the main administrative office.

# ACADEMIC CALENDAR

## 1993-1994

### FALL 1993

Mon.-Fri., Aug. 30, 31, Sept. 1-3  
Registration

Monday, September 6  
NO CLASSES (Labor Day)

Wednesday, September 8  
Classes starting 4pm or later begin  
NO DAY CLASSES (8am-3:35pm)

Thursday, September 9  
DAY CLASSES BEGIN

Wednesday, September 15  
(Rosh Hashana)  
NO CLASSES beginning 4pm or later

Thursday, September 16  
NO CLASSES (Rosh Hashana)

Friday, September 24  
NO CLASSES beginning 4pm or later

Monday, November 22  
Thursday classes meet  
(Make-up for Sept. 16)

Thursday, Friday, Nov. 25, 26  
NO CLASSES (Thanksgiving Recess)

Monday, December 13  
CLASSES END

Monday, December 14  
Reading Day

Wednesday, Dec. 15-Thursday, Dec. 23  
FINAL EXAMS

Monday, December 27, 1993-Monday,  
January 3, 1994

Recess-SCHOOL CLOSED

Tuesday, Jan. 4, 1994-Tuesday,  
Jan. 18, 1994

Intercession/Spring Mini Session  
(NO CLASSES-Mon., Jan. 17, 1994)

### SPRING 1994

Monday, January 17  
Holiday (Martin Luther King, Jr. Day)

Wed., Jan. 19-Tues., Jan. 25  
Registration

Thursday, Jan., 27, 1994  
CLASSES BEGIN

Monday, March 28-Friday, April 1  
SPRING RECESS

Wednesday, May 4  
CLASSES END

Thursday, May 5  
Reading and Make-up day

Friday, May 6-Monday, May 16  
FINAL EXAMS

Tues., May 17-Tues., May 31, 1994  
Intercession/Summer Mini-session

Sunday, June 5  
Commencement

### SUMMER 1994

Wed., Thur., May 25, 26  
Registration

Monday, May 30  
Holiday (Memorial Day)

Wednesday, June 1  
Classes Begin for "X" & "Z" session

Monday, July 4  
NO CLASSES

Friday, July 8  
Monday classes meet (Make-up)

Tuesday, July 12  
Classes end for "X" session

Wednesday, July 13  
Classes begin for "Y" session

Tuesday, August 23  
Classes end for "Y", "Z" sessions

## 1994-1995

### FALL 1994

Mon.-Fri., Aug. 29-31, Sept. 1-2  
Registration

Monday, September 5  
NO CLASSES (Labor Day)

Wednesday, September 7  
Classes starting 3:35pm or later begin  
NO DAY CLASSES (8am-3:30pm)

Thursday, September 8  
DAY CLASSES BEGIN

Wednesday, September 14  
(Yom Kippur)

NO CLASSES beginning 3:35pm or later

Thursday, September 15  
NO CLASSES (Yom Kippur)

Friday, September 24  
NO CLASSES beginning 4pm or later

Monday, November 21  
Thursday classes meet  
(Make-up for Sept. 15)

Thursday, Friday, Nov. 24, 25  
NO CLASSES (Thanksgiving Recess)

Monday, December 12  
CLASSES END

Tuesday, December 13  
Reading Day

Wednesday, Dec. 14-Friday, Dec. 23  
FINAL EXAMS

Saturday, December 24, 1994-Sunday,  
January 1, 1995  
Christmas Recess-SCHOOL CLOSED

Monday, Jan., 2, 1995-Tuesday,  
Jan. 17, 1995

Intercession/Spring Mini Session begins  
Jan. 3

### SPRING 1995

Monday, January 16  
Holiday (Martin Luther King, Jr. Day)

Wed., Jan. 18-Tues., Jan. 24  
Registration

Thursday, Jan., 26, 1994  
CLASSES BEGIN

Monday, April 10-Friday, April 14  
SPRING RECESS

Wednesday, May 3  
CLASSES END

Thursday, May 4  
Reading Day

Friday, May 5-Tuesday, May 16  
FINAL EXAMS

Wed., May 17-Wed., May 31, 1994  
Intercession/Summer Mini-session

# ACADEMIC CALENDAR

## SUMMER 1995

Wed., Thur., May 24, 25  
Registration  
Monday, May 29  
Holiday (Memorial Day)  
Wednesday, MAY 31, 1995  
Classes Begin for "X" & "Z" session  
Tuesday, July 4  
NO CLASSES  
Friday, July 7  
Tuesday classes meet (Make-up)  
Tuesday, July 11  
Classes end for "X" session  
Wednesday, July 12  
Classes begin for "Y" session  
Tuesday, August 22  
Classes end for "Y", "Z" sessions

**1995-1996**

## FALL 1995

Thurs., Aug. 24, Mon.-Thurs.,  
Aug. 28-31  
Registration  
Monday, September 4  
NO CLASSES (Labor Day)  
Tuesday, September 5  
Classes starting 3:35pm or later begin  
NO DAY CLASSES (8am-3:30pm)

Wednesday, September 6  
DAY CLASSES BEGIN  
Tuesday, October 3  
NO CLASSES beginning 3:35 or later  
Monday, September 25  
(Rosh Hoshana)  
NO CLASSES  
Wednesday, October 4  
NO CLASSES (Yom Kippur)  
Monday, November 21  
Thursday classes meet  
(Make-up for Sept. 15)  
Thursday, Friday, Nov. 24, 25  
NO CLASSES (Thanksgiving Recess)  
Monday, December 11  
CLASSES END  
Tuesday, December 12  
Reading Day  
Wednesday, Dec. 13-Friday, Dec. 22  
FINAL EXAMS  
Saturday, December 23, 1995-Sunday,  
January 1, 1996  
Christmas Recess -SCHOOL CLOSED  
Tuesday, Jan., 2, 1996-Tuesday,  
Jan. 16, 1995  
Intercession/Spring Mini Session  
(NO CLASSES-Mon., Jan. 15, 1994)

## SPRING 1996

Monday, January 15  
Holiday (Martin Luther King, Jr. Day)  
Wed., Jan. 17-Tues., Jan. 23  
Registration

Thursday, Jan., 25, 1996  
CLASSES BEGIN  
Monday, April 1-Friday, April 5  
SPRING RECESS  
Wednesday, May 1  
CLASSES END  
Thursday, May 2  
Reading Day  
Friday, May 3-Tuesday, May 14  
FINAL EXAMS  
Fri., May 17-Fri., May 31, 1996  
Intercession/Summer Mini-session

## SUMMER 1996

Monday, May 27  
Holiday (Memorial Day)  
Wed., Thur., May 29, 30  
Registration  
Monday, June 3, 1996  
Classes Begin for "X" & "Z" session  
Thursday, July 4  
NO CLASSES  
Friday, July 5  
Thursday classes meet (Make-up)  
Thursday, July 11  
Classes end for "X" session  
Monday, July 15  
Classes begin for "Y" session  
Thursday, August 22  
Classes end for "Y", "Z" sessions

# POLYTECHNIC UNIVERSITY PROFILE

## INTRODUCTION

Polytechnic is a coeducational, independent private university accredited by the Middle States Association. Undergraduate programs in aerospace, civil, computer, chemical, electrical, and mechanical engineering are accredited by the Accreditation Board for Engineering and Technology (ABET). The undergraduate program in computer science is accredited by the Computer Science Accreditation Board (CSAB), and the undergraduate chemistry program is approved by the American Chemical Society.

The student body includes over 1600 undergraduates and 2000 graduate students. The graduate enrollment in engineering is among the largest in the nation. Polytechnic consistently ranks among the top five universities in the number of graduate engineering degrees awarded. The majority of its students live in the New York metropolitan area, but many students come from throughout the country and the world to study at Polytechnic as well. About 13% of the student population are women, about 11% are Black and Hispanic, and about 30% are Asian. Polytechnic is among the leading private universities in the nation in awarding engineering degrees to women and under-represented minorities.

Undergraduate programs at Polytechnic prepare students in Engineering and Science equally for immediate entry into the professional practice of their specialties or for continued graduate study at Polytechnic or other leading graduate institutions. Polytechnic ranks eighth in the nation in the percentage of its graduates who go on to receive a Ph.D. in engineering or empirical science, and has an excellent placement record for those students entering the job market.

Beginning in their first semester, Polytechnic students are taught by a world-class faculty. Polytechnic believes that the primary mission of its faculty is undergraduate and graduate education. Even its most prestigious researchers teach regularly, exposing students to leading professionals who are engaged in advancing the state-of-the-art in their specialties.

Polytechnic graduates enjoy an outstanding reputation with both public and private employers, and many have achieved remarkable success. Approximately 1 of every 30 Polytechnic graduates is a company president or high executive. About 100 CEO's on Long Island alone are Polytechnic graduates. Four Polytechnic alumni are currently the Presidents of prestigious universities in the U.S. and abroad. There are more than 165 Polytechnic alumni who have been named fellows of the Institute of Electrical and Electronics Engineers, and numerous others who are fellows of other professional organizations.

## HISTORY

Polytechnic is the second oldest private institution of science and engineering in the U.S. It was founded in 1854 as the Brooklyn Collegiate and Polytechnic Institute. In 1869, the Board of Regents authorized Polytechnic's collegiate department to confer Bachelor of Science and Bachelor of Arts degrees, the first of which were conferred in 1871. In 1889, the institution adopted the name "Polytechnic Institute of Brooklyn" and in 1901 offered its first Master of Science degree. An evening graduate program was instituted in 1920, and Polytechnic's first Ph.D. was granted in 1935.

In 1961, Polytechnic opened its Long Island Center at Farmingdale as a graduate

and research center. In 1974, it began offering undergraduate programs at Farmingdale. In 1975, the Westchester Graduate Center at White Plains was opened, and in 1987 moved to its current location in Hawthorne.

In 1973, the New York University School of Engineering and Science merged into the Polytechnic Institute of Brooklyn to form the Polytechnic Institute of New York. The merged institution was granted university status by the NYS Board of Regents and was officially renamed Polytechnic University in 1985. To this day, the University is often referred to by its historic nickname, "Brooklyn Poly."

## ACADEMIC PROGRAMS

Polytechnic offers Bachelor of Science degrees in 12 disciplines covering engineering, the physical sciences, mathematics, and the liberal arts. Master of Science degrees are offered in 23 disciplinary specialties. The Ph.D. is offered in 13 disciplines.

Bachelor of Science programs prepare students for entry level employment in the various professional disciplines, as well as for study at an advanced level. Master of Science programs are oriented towards professional development in the subject area, and can be arranged to provide the core coursework for Ph.D. study. The Ph.D. is the terminal research degree for those seeking careers in industrial or academic research. It requires an independent research dissertation which advances the state-of-the-art in the discipline of study. Details of academic degree requirements and detailed program descriptions are given in Part II of this catalog.

**ACADEMIC  
DEPARTMENTS**

This catalog is arranged by academic program area. All programs are administered by academic departments as indicated in the program descriptions. A listing of academic departments at Polytechnic is shown below.

- Aerospace Engineering
- Chemistry
- Chemical Engineering
- Civil and Environmental Engineering
- Computer Science
- Electrical Engineering
- Humanities and Communications
- Management
- Mathematics
- Mechanical and Industrial Engineering
- Materials Science and Engineering
- Physics
- Social Sciences

***School of Electrical Engineering and Computer Science***

The School of Electrical Engineering and Computer Science was formed in 1990 to house the university's two largest academic departments, and to provide greater visibility and administrative support to these activities. In 1993, the Department of Mathematics opted to join the School to enhance the research and educational interactions between the Mathematics faculty and the faculty in Computer Science and Electrical Engineering.

***School of Chemical and Materials Sciences***

The School of Chemical and Materials Sciences was formed in 1992 to bring together the University's diverse strengths across the general area of materials. The School includes the Departments of Chemistry, Chemical Engineering, and Materials Science and Engineering, as well as the Polymer Research institute.

**RESEARCH  
PROGRAMS AND  
CENTERS**

Polytechnic University maintains major programs in experimental and theoretical research, making significant contributions to the advancement of the state-of-the-art in many areas of technology. Polytechnic faculty have been and continue to be among the world's leaders in such diverse areas as electromagnetics and wave propagation, telecommunications, polymer chemistry and engineering, condensed matter and plasma physics, chemical and electronic imaging, materials science and engineering, transportation and traffic engineering, geotechnical engineering, software engineering, and others.

In 1992, Polytechnic University conducted over \$10 million of sponsored research under contracts and grants, of which 75% were funded by the federal and state governments and 25% by private industry. Over 90 faculty members were involved in these efforts, which also provided support for over 70 research fellows.

Research at Polytechnic is conducted either through academic department structures, or through one of seven major interdisciplinary research centers, each of which is briefly described below:

***CENTER FOR APPLIED  
LARGE-SCALE COMPUTING  
(CALC)***

This center focuses on research involving very large, heterogeneous, distributed data-base systems. Research topics include efficient methods for data storage, data transformation and compression, information retrieval technologies, user interfaces, computationally intensive applications, protocols for gigabit networks, image compression and transmission, and related areas.

***CENTER FOR ADVANCED  
TELECOMMUNICATIONS  
TECHNOLOGY (CATT)***

The State of New York has designated Polytechnic as a center for advanced technology in the field of telecommunications. This designation recognizes Polytechnic's strong contributions in electrical engineering and computer science, particularly in telecommunications applications. New York State provides significant annual funding

which must be matched from industrial sources. Research topics include dynamic routing, high-speed networks, local area networks, network management and control, optical communications, opto-electronic device structures, routing algorithms, superconducting thin films, superconductor devices, wireless information systems, and related areas.

***ENERGY SYSTEMS  
LABORATORIES (ESL)***

This is Polytechnic's newest research center, founded in Fall 1992. It focuses on a variety of energy-related research topics, including energy conversion and conservation, HVAC systems, heat pump performance, residential energy consumption patterns, electronic materials, and related areas.

***INSTITUTE FOR IMAGING  
SCIENCES (IIS)***

This center focuses on research in both chemical and electronic imaging and imaging systems. Research topics include image processing, image compression and reconstruction, machine vision and pattern recognition, acoustic-electron and electron-tunneling microscopes, photo-polymers, and microlithography.

***POLYMER RESEARCH  
INSTITUTE (PRI)***

PRI was founded by Dr. Herman Mark in 1942, and has been a vital part of the discovery, development, and application of polymeric materials ever since. Research covers virtually all aspects of polymers, including functionalization, blends, optical activity, conductive systems, photoreactive systems, membranes, rheological properties, composites, flammability, and processes.

***TRANSPORTATION  
TRAINING AND RESEARCH  
CENTER (TTRC)***

TTRC represents one of the newer and stronger areas of research for the Polytechnic. Founded in 1975, the Center has played a leading role in the development of highway capacity analysis and design procedures and criteria which are widely used throughout the U.S. and the world. Other research focuses include transportation noise abatement; policy studies involving van-pooling, express buses, and services for the physically and economically dis-

advanced, intelligent vehicle highway systems (IVHS), transit management, and computer applications.

**WEBER RESEARCH INSTITUTE (WRI)**

Founded in 1943 as the Microwave Research Center, the center was renamed in 1985 in honor of its founder, Dr. Ernst Weber. The center played a key role in WWII in the development of electromagnetic and microwave defense and communication systems. Research continues to focus on these and other areas such as electromagnetic propagation and material interactions, antennae, pulse power, power conditioning, acoustics, gaseous electronics, plasma physics, solid state materials, quantum electronics, and electric power engineering.

Many of these research centers also sponsor continuing education efforts in areas related to their research mission. CATT developed two executive format M.S. programs offered jointly by the Departments of Electrical Engineering, Computer Science, and Management. WRI, PRI, TTRC, and ESL all sponsor colloquia and/or continuing education programs.

Significant research efforts also occur outside these centers within academic departments. The Department of Civil and Environmental Engineering is developing a strong base in infrastructure research; the Department of Materials Science and Engineering has historically had, and continues to have, a strong research effort in exotic alloys and applications; the Department of Chemistry has a number of efforts not related to Polymers which are administered in the department.

**FACULTY**

The heart of the Polytechnic is its distinguished teaching and research faculty. Numbering some 170, the Polytechnic faculty is committed to providing the best possible educational environment in the classroom, in the laboratory, through individual guided studies and projects, through advising, and through the strong one-on-one relationship most faculty members develop with their students.

The faculty originates, organizes, and approves all curricula taught at the

University, and also establishes the academic standards for student performance. Polytechnic undergraduates interact with faculty from their first day of classes. Class sizes are relatively small, and all faculty maintain regular office hours for consultation with individual students. As many of the faculty are actively involved in on-campus research, they are easily accessible outside of the classroom. All formal academic advising after the first semester is done by the faculty.

The Polytechnic faculty is one of the most distinguished in the world. Polytechnic faculty were among the founders of the National Academy of Engineering, the Institute for Electrical and Electronics Engineers, the American Institute of Chemical Engineers, and the American Society of Engineering Education. The faculty includes four current members of the National Academy of Engineering, and numerous fellows of the various professional disciplinary organizations. Polytechnic faculty have authored numerous undergraduate and graduate textbooks used throughout the U.S. and abroad, and edit leading professional journals. Faculty are frequently honored with prestigious awards, including the following recent achievements:

- **George Bugliarello**, *President*, National Academy of Engineering
- **Ernst Weber**, *President Emeritus*, National Medal of Science, National Academy of Engineering.
- **Athanasios Papoulis**, *University Professor*, Humbolt Award, IEEE Education Medal.
- **Nathan Marcovitz**, *Professor Emeritus of Electrical Engineering*, IEEE Microwave Career Award, IEEE Herz Medal.
- **Erich Kunhardt**, *Professor of Electrical Engineering and Physics*, Halliburton Excellence in Research Award.
- **Herbert Morawetz**, *Professor Emeritus of Chemistry*, American Chemical Society Award in Polymer Chemistry.
- **Leopold Felsen**, *University Professor*, Herz Medal of IEEE, Humbolt Award, National Academy of Engineering.
- **Dante Youla**, *University Professor*, IEEE Field Award in System Science and Engineering, National Academy of Engineering.

- **Eli Pearce**, *University Professor*, Society of Plastics Engineers International Award in Education, Paul J. Flory Award in Polymer Education.
- **Otto Vogl**, *Herman Mark Professor of Polymer Science*, American Institute of Chemists Pioneer Award, Japan Prize in Polymer Chemistry.
- **Donald Othmer**, *Professor Emeritus of Chemistry*, Perkin Medal in Applied Chemistry.

**ALUMNI**

The Alumni Association fosters fellowship and sponsors activities for the alumni and students, including continuing education programs, professional career placement, and new student recruiting. The Association helps sponsor the annual Freshman Orientation and presents career symposia featuring prominent alumni speakers.

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

The Alumni Association has established a student committee to work closely with the Association's Board of Directors to promote collaboration between alumni and current students, to develop programs whereby student alumni mutual interests can be more fully realized, and to acquaint students with the benefits to be derived by becoming active alumni upon graduation.

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

Alumni residing outside the New York City region have formed various Poly Groups, providing opportunities for formal and informal alumni gatherings, and providing an opportunity to represent Polytechnic to the community. Large groups now exist in several areas of the nation, and in several foreign countries.

Alumni are offered a special, non-credit, reduced tuition, audit option on all courses.

**CAMPUS CENTERS**

The campus centers and accompanying facilities are described in greater detail in the sections which follow, along with the types of programs offered at each.

**The Brooklyn Center at Metrotech  
Six Metrotech Center  
Brooklyn, New York 11201  
(718) 260-3600**

The Brooklyn Center is the focus of an exciting new environment with the arrival of Metrotech, a joint University - industry development now nearing completion. After over 12 years of planning, Metrotech is now a reality. Four major industrial companies share a common campus with Polytechnic University, with the University as its core. This new urban campus is surrounded by five new corporate and university buildings:

- **Dibner Library/Center for Advanced Technology in Telecommunications** Polytechnic's new academic building houses a new state-of-the-art library, two of its prestigious research centers (CATT and CALC), and the Departments of Electrical Engineering and Computer Science. The new building, which opened in January of 1992, provides 128,000 square feet of new academic space, and anchors the north end of the new campus.
- **Securities Industry Automation Corporation (SIAC)**, which operates the computer information networks of the New York and American Stock Exchanges and their transaction clearing operations, has moved its headquarters to Metrotech. The new 533,000 square-foot office and data processing complex opened in September of 1990, and anchors the south end of the new campus.
- **Brooklyn Union Gas Company** has also moved its headquarters to Metrotech. The new 845,000 square-foot office facility is now complete and occupied. Bear Stearns, a major brokerage house, became a major co-tenant of this building in June, 1992.

- **Chase Manhattan Bank** is building two major office facilities totalling approximately 1.5 million square feet of office/data processing space. Occupancy of these buildings began in the Spring of 1992.

These new buildings, as well as Polytechnic's existing academic buildings, surround a three acre joint campus area. A closed pedestrian environment was created on the campus by closing all streets formerly running through the Metrotech area. As of spring 1992, all of the buildings noted above and the joint campus area were completed, bringing to fruition a dramatic concept in university-industry cooperation introduced by Polytechnic University over a decade ago.

In addition to a radically new environment and a new building, Polytechnic has already begun to develop interactions with its Metrotech neighbors. These corporations, all major employers, are heavily involved in communications technology, and Polytechnic is already working on joint research and educational programs in this critical area.

The Brooklyn Center at Metrotech is located at a major junction of public transportation routes, and is easily accessible by auto from the Brooklyn or Manhattan Bridges or the Brooklyn-Queens Expressway. All of the new commercial buildings of Metrotech have parking facilities, and Polytechnic continues to maintain a small parking facility of its own. The Brooklyn Center is easily accessible from all parts of New York City, Long Island, New Jersey, and Connecticut.

The Brooklyn Center consists of several significant buildings:

- **Rogers Hall**, named after Dr. Harry Stanley Rogers, Polytechnic's fifth president, is the main academic building. It houses faculty and administrative offices, classrooms, research and teaching laboratories and student areas. The Office of the Vice President for Academic Affairs and Dean of Engineering is located in Rogers Hall.
- **The Jacobs Building** is named after Dr. Joseph Jacobs, the former and current Chairman of the Polytechnic Board of Trustees, and a major benefactor to the University. It houses primarily administrative and faculty offices. Offices of the President, Senior Vice Presidents for University Advancement

and Finance and Administration are located in the Jacobs Building. Most student service offices are also located here, including the Office of Admissions, Registrar, Bursar, Financial Aid, and Research and Graduate Studies. Business-related functions of the Polytechnic are also housed in Jacobs.

- **The Dibner Library/Center for Advanced Technology in Telecommunications** is Polytechnic's first new academic building in Brooklyn, and has been described previously.
- **William H. Nichols Hall**, located just opposite the Dibner Library/ CATT Building, houses faculty offices, laboratories, and classrooms. The Department of Physics, ROTC, and the Office of Career Services are located in Nichols Hall. Over the next five years, it is expected that Polytechnic will vacate this building, gradually moving these functions into vacated areas of Rogers Hall, or into another facility.

The Brooklyn Center represents a major renaissance in which Polytechnic is the center of one of the most unusual and successful joint university-industry-public ventures in the nation. For Polytechnic students, it means a new urban campus, markedly improved surroundings, a dramatic new library, new homes for Electrical Engineering, Computer Engineering, and Computer Science programs, and the opportunity to interact with major information industries.

**The Long Island Center  
at Farmingdale, Route 110  
Farmingdale, New York 11735  
(516) 755-4300**

The Long Island Center is located on Route 110, one mile east of the Nassau - Suffolk county border. It is next door to Republic Airport and is located in a rapidly growing corridor of industrial and business activity which stretches both north and south along Route 110. It is located on 25 acres of land near scores of Long Island high-technology industries.

Most engineering undergraduate programs and many graduate engineering and management programs are available at the Long Island Center, which currently serves approximately 500 undergraduates and 400 graduate students. The world renowned

Weber Research Institute for electrophysics research is located at the Long Island Center, as are the University's unique aerospace laboratories.

- **The Main Administration Building** houses administrative and faculty offices, classrooms, a cafeteria, the Long Island Center Library, a student lounge, conference and meeting rooms, and research and teaching laboratories.
- **The Preston R. Bassett Building** houses the Weber Research Center, its offices and laboratories, faculty offices, and teaching and research laboratories.
- **Grumman Hall**, the student center, houses a lounge, game room, bookstore, student organization offices, the Career Services Office, and the Student Life office.
- **East Residence Hall** consists of apartment-style suites, each containing four single bedrooms and a common room with cooking facilities. The facility accommodates 50 students.
- **West Residence Hall** was opened in January 1991, and contains double-occupancy rooms and a large lounge. No cooking facilities are available in West Hall, and all students residing here are required to be on a meal plan. The facility accommodates 40 students.
- **The Gymnasium** is utilized for inter-collegiate, intramural, and recreational sports. It consists of a multipurpose gym floor, a weight room, and a wrestling room. The Gymnasium is also the site for special student and outside activities.

**The Westchester Center at Hawthorne**  
**36 Saw Mill River Rd.**  
**Hawthorne, New York 10532**  
**(914) 347-6940**

The Westchester Center offers only graduate programs, serving scientists, engineers, and managers employed in the high-technology companies of the Lower Hudson Valley, as well as southern Connecticut and northern New Jersey. The Center fulfills their educational needs through provision of part-time graduate degree programs and specialized continuing education programs.

To serve this unique population, most

classes at the Westchester Center are held in the late afternoon, evenings, and/or on Saturdays. Programs are offered in Electrical Engineering, Computer Science, Metallurgy and Materials Science, Chemistry, Management, Manufacturing Engineering, Telecommunications and Computing Management, and Information Systems Engineering, the latter two in executive format, meeting on alternate Fridays and Saturdays throughout the semester.

This modern facility contains classrooms, administrative offices, the Richard Laster Library, a computer terminal laboratory, and a microcomputer laboratory.



The goal of Polytechnic Libraries is to satisfy the recorded information and document needs of the students, faculty, and administration supporting the undergraduate, graduate, and research programs. Highly skilled librarians and information specialists offer the following services:

- Circulation of a book collection of over 100,000 volumes and a large course reserve collection.
- Reference assistance to locate the book, article, or information at Polytechnic or other locations which meets users' needs.
- An active interlibrary loan program capable of locating and retrieving books through a powerful international computer system (OCLC, with about 3,000 libraries). Membership in cooperatives such as the Academic Libraries of Brooklyn, the New York Metropolitan Reference and Research Library Agency, and the Long Island Library Resources Council provides additional interlibrary loan access, and on-site access and circulation privileges at many area libraries.
- Database searching capability, available at cost, to do detailed author, title, or subject searches in virtually any area of interest from over 250 computerized databases, some of which provide full abstracts of relevant papers and articles.
- CD-ROM search capability in five categories of databases: journal citations, free text, full text image, monograph citations/abstracts, and reference works.

This system is being constantly expanded, and is a major component of the Dibner Library.

- InfoDash, a service which retrieves journal articles from the Polytechnic Libraries or any of the major New York metropolitan area libraries.
- Other services include library orientations for all students, requested classroom instruction on specific aspects of library use, maintenance of over 1200 journals, an excellent collection of encyclopedias, almanacs, indices and abstracts, biographical dictionaries, and other reference material.

The Bern Dibner Library opened in January of 1992. It replaced the Spicer Library as the Brooklyn Center Library, and is the center of state-of-the-art electronic search and retrieval facilities serving all three Polytechnic campus centers.

The new library occupies two floors of Polytechnic's new building at Metrotech, and doubles the amount of space available for book and journal collections, and greatly expands the amount of study and reading space available for students, faculty, and staff. Expanded facilities for reading microfiche and microfilm, as well as video facilities are provided. Individual study carrels provide study space for individuals, while a set of study rooms can be reserved for group study.

This new \$15,000,000 library and information center accesses information electronically from resources throughout the nation and the world. It is a prototype for advanced electronic information centers to follow, and enables users in homes, offices, classrooms, and laboratories as well as libraries to locate and retrieve information, books, journal articles, or other documents.

The Long Island Center Library is electronically connected to the Brooklyn Center, and offers the same services as provided in Brooklyn. The on-site collection is smaller, but all books and journals at any Polytechnic location can generally be acquired within 24 hours.

The Richard Laster Library serves the Westchester Center, and is available during the normal operating hours of the Center. It is also electronically connected to the Brooklyn Center, and all services are available. The library maintains a small on-site collection serving those graduate programs given at the Westchester Center.

**POLYTECHNIC  
COMPUTING  
FACILITIES**

Computing facilities at Polytechnic are continually undergoing expansion in terms of the number and power of computers, and the range of software services provided. Polytechnic's student-to-device ratio now stands at 8:1, and is continually declining. All three campuses are electronically linked, and all mainframe facilities can be accessed from any Polytechnic campus center, as well as by dial-up from an external location.

The Polytechnic Information Technology Systems unit provides a wide range of equipment and services which are available to the entire University community: students, faculty, researchers, and administrative personnel.

Polytechnic students have access to a wide variety of computing equipment, operating systems, and software. Available

equipment includes a mini-supercomputer, mainframe computers, minicomputers, workstations, personal computers, and graphic terminals. Ethernet is used to link computers on all three campuses, and access is provided to several global networks, including Internet, NYSERnet, BITNET, and Usenet. Unix, DOS, and Windows are the most frequently-used operating systems, but others are also available. Most programming languages are available, as are word processors, spreadsheets, graphics packages, and a wide variety of special-purpose software.

Each Polytechnic campus center has general-use terminal and microcomputer laboratories available. In addition, many departments including computer science, electrical engineering, civil engineering, mechanical and industrial engineering, chemical engineering, physics, and others maintain dedicated special-use computer facilities for their students and faculty. Several of Polytechnic's research centers including CATT and WRI also maintain dedicated computer facilities for research purposes.

All Polytechnic computer facilities are managed and supported by the Data Processing Center and its staff. The Center supports a wide range of languages and operating systems, word processing and spreadsheet systems, and specialized software for graphics and other purposes, as noted above. The Center provides a full-time systems programming staff which is available to assist students and faculty, and staffs University computing laboratories with full-time and part-time consultants. The Association for Computing Machinery (ACM) is a student organization which provides extensive user support services, including debugging assistance, distribution of software documentation, and seminars on facility use.

Dial-up lines are available to students, faculty, and staff at all times, 24 hours per day, 7 days per week.

# ACADEMIC PROGRAMS AND POLICIES

## PROGRAM AREAS

Polytechnic is a university uniquely focused on the world of technology and its interactions with society. To fulfill this mission, Polytechnic offers degree programs in four general academic areas:

- Engineering
- The Sciences and Mathematics
- Management
- Liberal Arts

### **ENGINEERING**

Engineering is perhaps best described as the creation of devices and implements which can control or manipulate nature to produce a desired effect. It is the application of science to the building of the infrastructure, devices, tools, and other implements of society in a way which will improve the quality of life and environment for all.

The modern engineer must have a firm background in the sciences which he or she will apply, as well as in mathematics, the language with which scientists describe nature and through which engineers manipulate it. The engineer must also have a background in the liberal arts, as no one can hope to improve society without understanding its character, needs, and desires. The modern engineer must also develop excellent communications skills, both to deal with fellow professionals as well as with decision-makers and the public.

Engineering programs at the Polytechnic build on a firm foundation of mathematics and science to develop the engineering analysis and design skills required of a practicing professional. Undergraduate programs prepare students equally for entry into the profession and for continued education at the graduate level.

Above all, an engineering education from Polytechnic prepares the graduate for a lifetime of education and growing knowl-

edge. The ability to continue learning is perhaps the most lasting gift of education, particularly in the rapidly-developing field of technology. By giving its students a comprehensive education in the principles of science and engineering, and by developing the creative skills required for engineering design and analysis, Polytechnic provides its graduates with the ability to continue to learn and grow as their careers progress.

Just as current Polytechnic faculty and alumni are advancing the state-of-the-art in such varied fields as telecommunications, microwaves, space electronics, imaging sciences, quantum electronics, pulse power, materials, aerospace, geotechnology, software engineering, earthquake performance of structures and numerous others, the Polytechnic engineer is equipped to carry this tradition forward to the next generation of technological breakthroughs.

### **THE SCIENCES AND MATHEMATICS**

Science and mathematics are the underpinnings of modern technology. As scientists and mathematicians discover and describe new secrets of the natural world around us, engineers look to apply them to the development of technology. Without the physical sciences and mathematics, engineers would have no tools with which to invent the technology of tomorrow.

Undergraduate science and mathematics programs at Polytechnic give the student a unique opportunity to study basic theory, while at the same time interacting with design disciplines. The structure of undergraduate programs in these areas allows students to select concentrations of elective courses in technology areas, and students are encouraged to do so.

Students are exposed to modern laboratories, and interact with faculty who are world-class researchers. As many junior and senior classes are quite small, students in these areas get to develop one-on-one relationships with faculty, and have the opportunity to work with them in their appropriate research areas.

The future of technology critically depends on our ability to develop a better and more accurate understanding of nature and its opportunities and constraints. For technology to advance, scientists must continue to unlock the secrets of the universe, and mathematicians must continue to develop the analytic and logical processes whereby we can extend and apply that which we discern. Polytechnic programs prepare scientists and mathematicians for this vital role, enabling them to lead us to a better future.

### **MANAGEMENT**

Management programs at Polytechnic focus on the management of technology. The management of top-flight technology is no longer a luxury in today's fast-paced industrial environment. Management of technology requires unique skills, and a firm understanding of where technology is going, and, just as importantly, how it is developed and supported.

Management of technology has two aspects. For the manager of a technology business or industry, the need to know how to support and nurture the development of a new technology or product is critical. Decision-making must recognize the need for research and product development and place this need into the traditional fiscal and operating requirements of an organization.

On another level, every commercial enterprise must now deal with complex technologies, including information systems, telecommunications, computers, automation, and the like. Managing these aspects of organizations also requires specialized skills and knowledge.

Management programs at Polytechnic combine the traditional skills and knowledge in basic management sciences with the very special needs of both businesses involved in the development, production, and sales of technology and those critical technology components of every commercial and public enterprise.

## LIBERAL ARTS

It is through the study of the liberal arts that we learn to understand human society, its development, its needs, its desires, and the means through which it makes these known. No one can adequately address technology, or its creation and development, without an adequate understanding of the human and societal needs which it seeks to serve. On the other hand, no humanist can adequately understand society and its development without a knowledge and understanding of how it interacts with and is affected by technology.

While studying traditional programs in social sciences and humanities, liberal arts majors at Polytechnic also take a curriculum specifically addressing the interactions between society and technology.

## SELECTION OF A MAJOR (UNDERGRADUATE STUDENTS)

Undergraduate students admitted to Polytechnic are permitted to declare their major immediately, should they so desire. Incoming freshman may initially enter as "undeclared" majors. For many freshman who wish to consider several program options, it is useful to delay the choice of a major.

Polytechnic's freshman year is uniform for all engineering majors, and very similar for other majors. Thus, students may delay their selection of a major until the end of the freshman year if they so desire. Such students will follow the "Core Curriculum for Engineering Majors" during their first year. This curriculum is detailed under "General University Degree Requirements" in Part II of this catalog.

Students are free to change their major at any time, given that their scholastic standing is acceptable to the program into which they wish to transfer. It should be noted that such changes may involve some loss of credit if done later than the end of the first year. Advisers will work with any student wishing to change majors to minimize the loss of credit and disruption to the student's educational program.

## ACADEMIC POLICIES

### DEFINITION OF 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 a minimum of either one 55-minute period of classwork, or three hours of undergraduate laboratory, over a period of 14 weeks. In a few cases, more time per credit is given. 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 classwork for a single semester carries 1-1/5 graduate units. A standard graduate course meeting for 2-1/2 55-minute periods per week would be equivalent to 3 units. This is the most common format for graduate courses. Graduate laboratories involve approximately twice this amount of time per graduate unit. Courses meeting more or less than 2-1/2 periods each week are assigned units in the appropriate proportion.

### CREDITS FOR COURSES TAKEN ELSEWHERE (TRANSFER CREDITS)

#### Residency

To earn a Polytechnic University degree, students must complete a minimum number of credits at the Polytechnic University. The minimum number of credits which must be completed at Polytechnic University to satisfy residency requirements is:

- *Bachelor of Science* 34 credits in approved Junior and Senior subjects
- *Master of Science* 27 units
- *Engineer* 27 units beyond the M.S.
- *Ph.D.* 30 units including dissertation
- *Graduate Certificate* 12 units

#### Undergraduate Students

Students who have completed some undergraduate courses at other colleges or universities are encouraged to consider transferring into Polytechnic programs. Polytechnic will award transfer credit for appropriate courses satisfactorily completed elsewhere. Students transferring to

Polytechnic from other universities must have transcripts of their courses examined by the Office of Admissions and an adviser from the student's major department to determine the acceptability of individual substitutions and general acceptance of credits from their former institution(s). Much of this can be accomplished during the application process if the student's records are complete. All evaluations of transfer credits must be completed by the end of the student's first semester of registration at the Polytechnic.

Transfer credit is never given for any course in which a grade less than "C" has been earned. In addition, any student completing a course at Polytechnic for which transfer credit has already been given automatically forfeits the transfer credit for that course.

The contents and standards of courses vary from school to school. Thus, a transfer student may find, after semester's work at Polytechnic, that he will be better prepared for advanced courses if he re-enrolls in a course at Polytechnic for which he has been given transfer credit. A student may be required to do this in consultation with his adviser. In some instances, course requirements may be waived for students who demonstrate sufficient knowledge of a specific course content through either written or oral examination given by the appropriate academic department. In such cases, no credit is awarded, but the student will be permitted to submit a more advanced course to satisfy degree requirements.

Grades of courses for which transfer credit is given are not included in the computation of the student's cumulative or current semester grade-point average.

Polytechnic will also grant students credit for appropriate Advanced Placement courses taken in high school, given acceptable performance on AP examinations. Credit may also be granted for college preview courses taken at Polytechnic or other universities while a high-school student, if these courses are relevant to the student's degree program and acceptable grades have been achieved. Grades for such courses are also not included in the computation of the cumulative or current semester grade-point averages.

#### Graduate Students

A limited number of units, consistent with residency requirements, for graduate courses completed with honor grades (A or B) from accredited institutions may be

allowed towards meeting the requirements for M.S., Ph.D., or graduate certificate programs. Courses must be acceptable at the transferring institution for similar degree programs, and must usually have been taken after receipt of a bachelor's degree. Evaluation of graduate transfer units is done by the student's major academic department.

Graduate courses taken at Polytechnic while a student is pursuing an undergraduate degree may be subsequently applied towards a graduate degree provided that they were not submitted in fulfillment of an undergraduate degree and a grade of B or higher was earned. Such courses are not subject to the 9-unit maximum transfer limitation for the M.S. degree and the grades are not figured into the cumulative grade-point average.

**Transfer Credits While in Residence**

Students enrolled at Polytechnic are expected to take coursework at Polytechnic University. Exceptions can be made in cases where Polytechnic does not offer courses of importance to the attainment of the student's academic goals.

To obtain credit/units for courses taken elsewhere while enrolled at Polytechnic, written permission must be obtained from the major academic adviser and the department head of the course for which transfer credit is requested. This must be done before registering for the course at another institution. Forms for such permission are available in the Office of the Registrar. The following requirements apply:

- The other institution must be accredited.
- Grades earned must be C or better for undergraduate courses and B or better for graduate courses.
- Pass/Fail courses are not acceptable under any conditions.
- Only credits/units will be granted; grades are not included in the computation of cumulative or current semester grade-point averages.

**CREDIT BY EXAMINATION  
(UNDERGRADUATE STUDENTS)**

Undergraduate students with an outstanding record or with specialized competence may establish a maximum of 18 credits towards 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 the approval of the department giving the course and the department of major study.

A grade of B+ or better is required to achieve credit by examination. Students who register for or attend a course at 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 and 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 or towards the grade-point average.

In the area of foreign languages, those presenting their native tongue or the language in which they were educated 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 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 more than one calendar year after the student begins study at the Polytechnic. A grade of C or better is required to validate course credits for undergraduate students; B or better is required for graduate students. An examination may not be taken more than once. A student who registers for or attends the course at Polytechnic forfeits the right to take a validation examination.

The sum of validation units, special student units, and transfer units, is limited to a maximum of nine units for the Master of Science degree.

**CLASS STANDING FOR 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:

<i>Freshman</i>	<i>1 - 27 credits</i>
<i>Sophomore</i>	<i>28 - 61 credits</i>
<i>Junior</i>	<i>62 - 94 credits</i>
<i>Senior</i>	<i>≥ 95 credits</i>

**MAXIMUM CREDITS PERMITTED AND REGISTRATION STATUS**

*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, ROTC cadets, etc.) must receive permission from the head of their major department for any program of more than 19 credits. Students who register for more than 20 credits will be charged the per credit rate for additional credits beyond 20.

**Part Time:** Students registered for less than 12 credits per semester (except summer) are considered part-time students. Part-time students pay tuition at the prevailing per credit rate, and are not eligible for most financial assistance programs.

**Summer and Intersessions:** Students may register for up to 7 credits during each six week summer term, and for no more than 14 credits for the combined twelve-week summer term. 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 the purposes of student records and credit.

*Graduates*

**Full Time:** Registration for 12 units or more categorizes graduate students as full time. Students who register for more than 20 units will be charged the per unit rate for additional units beyond 20.

**Part-Time:** Students registered for less than 12 units per semester (except summer) are considered to be part-time students. Part-time students pay the per unit tuition rate, and do not qualify for most financial assistance programs.

## ACADEMIC PROGRAMS AND POLICIES

**International students (undergraduate and graduate)** on F-1 or J-1 visas are required to enroll in a full-time program of study each semester.\*

\*For certain types of attendance and enrollment certifications, some students who are registered for less than 12 credits or units may be certified as full-time, specifically, undergraduates who are pursuing University authorized full-time, full semester COOP work assignments; and graduate students pursuing research projects which their department head certifies in writing to the Registrar as full-time. A form to establish full-time equivalency is available from the Office of the Registrar.

### POLICIES ON GRADING AND GRADES

#### Computing the Grade-Point Average for Undergraduate Students

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 various letter grades:

Grade	Point Value	Description
A	4.0	Excellent
A-	3.7	Excellent
B+	3.3	Good
B	3.0	Good
B-	2.7	Good
C+	2.3	Passing
C	2.0	Passing
C-	1.7	Deficient, but passing
D+	1.3	Deficient, but passing
D	1.0	Deficient, but passing
F	0.0	Failing
S		Satisfactory
U		Unsatisfactory
W		Withdrawal
I		Incomplete
NR		Not Received**
P		Passing**

\* Grade not received by Registrar in time to report it.

\*\* Only used in optional PE courses.

In computation of the grade-point averages, courses graded W, I, S, or U are not considered, nor do they count towards the computation of total credits passed or earned. Grade-point averages are computed by multiplying the numerical grade in each course by the number of credits for each course, adding these products for the courses taken and then dividing this sum by the total number of credits represented by the courses considered.

The W and I grades are described in greater detail in subsequent sections. Grades of S or U are used to indicate progress in multi-semester research projects or theses, or for non-credit bearing remedial or other courses. Undergraduates enrolled in graduate courses may not receive plus or minus grades.

#### Computing the Grade-Point Average for Graduate Students

For the purposes of computing grade-point averages for graduate students and graduate courses, the following schedule is used. Note that the range of grades for graduate students is limited to A, B, C, and F.

Grade	Point Value	Description
A	4.0	Excellent
B	3.0	Good
C	2.0	Deficient, but Passing
F	0.0	Failing
W		Withdrawal
I		Incomplete
AUD		Audit
S		Satisfactory
U		Unsatisfactory
NR		Not Received

Grades S and U are used to reflect progress on continuing research efforts until they are completed, at which time the appropriate letter grade is entered on the transcript. Non-credit seminar courses are also graded S or U. Grades S, U, I, W, and AUD are not included in the computation of the grade-point average, which is computed as indicated for undergraduate students.

#### Repeating Courses

**Undergraduates:** If an undergraduate takes a course two or more times, only the second and subsequent grades will count towards the student's grade-point average. This policy holds regardless of the first and second grades earned, even when the second grade is lower than the first. The repeated course must be taken within one year of the first course, or at the first time it is offered, where a course is not available to repeat within one year.

**Graduates:** The first time a graduate student repeats a course, the lower grade will not be counted towards the grade-point average. All subsequent grades in a course repeated

more than once will be included in the grade-point average, although degree credit is earned only once.

#### Course Withdrawal - the "W" Grade

Students may withdraw from a course or courses without academic penalty through the 10th week of the normal Fall or Spring semester. Approval by the instructor of the course is not required, but the withdrawal form must be signed by the student's major academic adviser. When the duration of the course varies from the norm, such as in 6, 9, or 12-week courses, withdrawal must be filed before two-thirds of the sessions are 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 course, withdrawal must be filed by 5:00 PM of the seventh class day. Students who file a course withdrawal form with the Office of the Registrar by the scheduled deadline will automatically receive a grade of "W." Once entered on the student's record, the grade of "W" may not be changed to any other grade under any circumstances. A grade of "F" will be recorded for any student who ceases to attend a course without formally withdrawing in the required fashion by the required deadline.

#### 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 "AUD" 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.

#### Incomplete Grades

When for valid reasons, such as illness or other **critical** emergency, a student is unable to complete the course work at the usual time, the instructor may give a grade or incomplete, "I." The date for completion will be inserted next to the I grade on the grade sheet and will be communicated directly to the student by the instructor

when possible. Whenever feasible, this date will not extend beyond the intersession, in fairness to students who finish course requirements on time, and to insure that students complete prerequisites necessary for taking advanced courses. On no account will this date be later than one year after completion of the semester for which the I was awarded.

The grade of I is used sparingly and only in cases with valid reasons, not merely because students have planned poorly or overloaded themselves. The I grade signifies that upon successful completion of the work, a passing grade will be issued.

An I grade lapses into a grade of F if the student fails to complete the course work within the specified completion date. If the 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.

**Continuation of Studies from MS to Ph.D**

Students who plan to pursue additional studies immediately following the award of an advanced degree by Polytechnic should complete a "Request for Continuation of Studies" form in lieu of a new application for admission, and hand it in for review and approval to the department in which the new degree will be pursued. This form is available from the Office of the Registrar.

**ACADEMIC STANDING AND PROBATION**

**Undergraduate Students**

To remain in good standing, undergraduate students must maintain term and cumulative grade-point averages of 2.00 or greater. In addition, students must successfully complete a minimum number of credits for each semester of full-time study, excluding summers and mini-sessions. In the case of part-time students, a "semester" indicates the points at which 12 or more credits are undertaken. Thus, the first semester of study ends where 12 credits are accumulated; the second is calculated from that time onward until 24 credits are accumulated. According to these semester equivalents, grade-point requirements for part-time students follow those for full-time students.

The minimum number of cumulative credits to be achieved by the close of each semester of full-time study appear below in Table 1:

**Table 1: Minimum Credits to be Earned vs. Semester of Full-Time Study**

SEMESTER	Minimum Credits Successfully Completed
I	6
II	18
III	30
IV	44
V	58
VI	73
VII	88
VIII	104
IX	120
X	136

In calculating the number of successfully completed credits:

1. Courses with 'F' grades do not count towards the criteria of Table 1.
2. Credits bearing the grade "F" and repeated within one academic year will be recalculated using the second grade earned, thus entering into the number of credits successfully completed (assuming that the second grade is not also "F") during the semester in which it is repeated.
3. Credits with the grade of "I" will be counted toward enrollment for one year. At the end of that time, any grade of "I" that has not been changed by the instructor of record will automatically lapse to a grade of "F".
4. Credits assigned a grade of "W" do not appear in the calculation of credits undertaken, earned, or successfully completed.
5. Transfer students will enter the standard as calculated from the point at which transfer credits place them.

A second requisite for enrollment is the maintenance of a grade-point average of 2.00 or above, or performance approaching 2.00 in a steady and realistic fashion. Table II contains the absolute minimum cumulative grade-point average to be achieved by the close of each semester of full-time or full-time equivalent enrollment.

**Table 2: Minimum Required Cumulative Grade Point Average by Semester**

SEMESTER	Minimum Cumulative G.P.A.
I	1.30
II	1.40
III	1.50
IV	1.67
V	1.78
VI	1.88
VII	1.95
VIII	2.00
IX	2.00
X	2.00

The Dean of Students provides regular academic monitoring of all undergraduate students in a system which includes: (1) a review of each student's academic record after each semester; (2) conferral with the student's academic adviser or other representatives from the student's major department; (3) meetings with those students determined to be encountering academic difficulties; and (4) assignment of an academic action code.

Students who are determined to be having academic difficulty will be placed on academic probation, according to the following steps and actions:

**Academic Warning:** Students whose grade-point averages approach 2.00 are placed on "academic warning." Letters are sent to these students warning them of potential problems, urging them to make use of the support services available to them, encouraging them to take whatever measures are necessary to maintain good standing and inviting them to meet with the Dean of Students.

**Academic Probation:** Students are placed on "academic probation" when their semester and/or cumulative grade-point averages fall below 2.00, but remain above the minimum standards of Table 2. Students falling into this category are notified by letter and are required to meet with the Dean of Students prior to registering for any further course work.

**Final Probation:** Students whose academic record indicates an unacceptable level of academic progress may be placed on "final probation". Notified by letter of

## ACADEMIC PROGRAMS AND POLICIES

their standing, these students are required to meet with the Dean of Students to determine a program of study geared towards improving their performance. Failure to improve their performance will result in disqualification. Students on final probation may not participate in early registration.

**Disqualification:** The Committee of Standing, comprised of the Dean of Students and a representative of the student's major department, shall jointly disqualify from the University any student whose cumulative average or number of credits successfully completed falls below the appropriate minima shown in Tables 1 and 2.

Additionally, a major department may disqualify a student at or above the minima listed, if it is indicated that continuation will not lead to a successful completion of degree requirements. Unless accepted into another department, a student so disqualified will not be permitted to reapply to the University 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 semester. Performance in the subsequent semester must meet minimal standards. Such arrangements must be made in concert with the head of the major department and the Dean of Students.

### **Dean's List:**

Undergraduate students who perform at a level of demonstrated excellence are recognized by their placement on the Dean's List. Undergraduate students who achieve both cumulative and semester grade-point averages of 3.40 or better, with no failures or incompletes, are commended by the Dean of Students and placed on the Dean's List. This list is posted semi-annually for full-time and annually for part-time students. Only those who complete 12 semester hours or more during a regular academic semester (or 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, provided that these courses represent no more than one-half of the credit load for a given period, and all of the aforementioned requirements are met. The Dean's List notation appears on the student's permanent record.

### **Graduate Students**

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 being placed on "academic probation."

After posting of the spring semester grades, graduate students whose cumulative grade-point average is below 3.0 will be notified that they are on academic probation. The data for such determination will be provided to the Dean of Research and Graduate Studies by the Registrar, and copies of probation notices will go to each department, where the accuracy of grade-point average determinations will be checked. Students with GPA's lower than 3.0 will be notified in August by the Dean of Research and Graduate Studies of their standing.

A major department may request that a graduate student be placed on academic probation at any time it finds a student falling below a 3.0 cumulative GPA. 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 the concurrence of the Dean 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. The statement will be kept on file in both the Office of Research and Graduate Studies and the major department office. A student may be denied permission to register by the academic department or the Dean of Research and Graduate Studies at any time while on academic probation. Students are cautioned that failure to maintain a 3.0 cumulative GPA 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.

## **WITHDRAWAL FROM THE UNIVERSITY**

### **Voluntary**

Students who withdraw completely during a semester which they are registered must notify the Dean of Students (undergraduates) or the Vice President for

Research and Advanced Programs (graduates). No withdrawal is official unless a written form is approved and submitted to the Office of the Registrar. Mere absence from courses does not constitute official withdrawal, but will lead to grades of "F" recorded for courses not completed.

### **Involuntary**

Polytechnic University is concerned about the health, safety, and well-being of its students. Therefore, a student who is judged to be a threat to himself or herself, or to others, may be involuntarily withdrawn from the Polytechnic. The University seeks, whenever possible, that such a student be allowed to continue as an active student if he or she agrees to involve himself or herself with appropriate care from a professional helper. Full details concerning this policy are available from the Department of Student Life.

## **LEAVES OF ABSENCE AND READMISSION**

### **Undergraduate Students**

An undergraduate student wishing a leave of absence must discuss this with the Dean of Students. A student desiring to re-enter after a one year or more period of absence must submit a request for readmittance by filing an application for readmission with the Office of Admissions.

### **Graduate Students**

Part-time students who last attended Polytechnic within a three-year period before the semester in which they seek to be readmitted need no formal readmission, and are automatically permitted to register. Part-time students who have not attended within the past 3 years must file an application for readmission which is available from the Admissions Office.

Full-time students who desire to interrupt their studies may request a leave of absence for a specified period of time, usually not exceeding one year. Such requests, when approved by the V.P. for Research and Advanced Programs, will constitute assurance of readmission to the degree program from which the leave was taken. When the period of absence exceeds the approved leave of absence, the student must apply for readmission.

Only if a part-time or full-time student has received an approved leave of absence will the time limitation on earning a graduate degree be extended by the period of the leave. Forms for requesting a leave of

absence are available from the Office of Research and Advanced Programs.

Once a Ph.D. 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 dissertation units. Students failing to obtain a leave of absence who subsequently wish to be readmitted may be required to register retroactively for those semesters not attended.

### ***THE FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT – THE BUCKLEY AMENDMENT***

The Family Rights and Privacy Act of 1974 (FERPA), as amended (also known as the Buckley Amendment) grants to students certain rights, privileges, and protections relative to individually identifiable student education records which are maintained by the University. Specifically, these include the right to:

- inspect and review the student's education records;
- request the amendment of such records to ensure that they are not inaccurate, misleading, or otherwise in violation of the student's privacy or other rights;
- consent to disclosure of personally identifiable information contained in the student's education records, except to the extent that Polytechnic's disclosure policy and directory information permits;

- obtain a copy of the Polytechnic's policy on meeting the requirements of FERPA, which is made available through the Registrar's Office on each campus; and
- file with the U.S. Department of Education a complaint concerning alleged failure by the University to comply with FERPA.

FERPA permits the release of directory type information to third parties outside the Polytechnic without written consent provided students have been given the opportunity to withhold such disclosure.

Polytechnic reserves the right to disclose the following information related to a student, which is considered "directory information:" the student's (1) name, (2) class year, (3) date/place of birth, (4) major field of study, (5) participation in officially recognized activities and sports, including weight and height of members of athletic teams, (6) dates of attendance at Polytechnic, (7) degrees and awards received, (8) the most recent previous educational institution attended by the student, (9) home and local addresses and telephone numbers, and (10) any other similar information (e.g. the title of the student's M.S. project or doctoral dissertation, distinguished academic performance). Currently registered students who wish to withhold directory information may do so by following the directions in the "Regulations on Privacy Rights for Students" brochure available from the Office of the Registrar.

### ***TRANSCRIPTS***

The issuance of transcripts, and generally the release of any information about a student is subject to the provisions of Public Law 93-380, "The Family Rights and Privacy Act" of 1974 as amended. Polytechnic has adopted regulations to implement the Act, and these can be found in the previous section.

Unless Polytechnic's disclosure policy permits otherwise, official transcripts of the scholastic record will be issued only upon the submission of a written request or upon the submission of a signed release from the student. Official transcripts will be sent directly to the school or other properly authorized parties. In no case can a student receive an official copy of his or her own transcript, unless specifically authorized by the Registrar. Such exceptions are strictly monitored, and are rarely given. Unofficial transcripts are available to any student upon written request. The first transcript will be issued without charge. There is a fee for each subsequent transcript issued.

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

Upon graduation, a student's transcript should be reviewed carefully and any errors immediately reported to the registrar before the record is sealed.

# CAMPUS LIFE AND SUPPORTING SERVICES

## DEPARTMENT OF STUDENT LIFE

The Department of Student Life is concerned with the holistic education and development of all Polytechnic students, both inside and outside the classroom. Responsible for the operation and maintenance of many student-oriented and student support programs and services, the Department of Student Life seeks to assist students in achieving success and enrichment in their endeavors at Polytechnic. Students needing assistance in resolving difficulties are encouraged to speak with a Student Life staff member. Some of the areas handled by this office include:

- freshman programs, such as the new student overnight, the freshman seminar (SL101), advising undeclared majors, programs for parents
- academic progress monitoring
- physical education and athletics
- student activities
- residence life and housing
- international student advising
- student leadership development
- counseling, advising, and student advocacy
- health insurance coordination
- academic and disciplinary policy administration

## 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 individualized study skills advisement or workshops dealing with 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 Office of Special Services. All tutorial, educational and counseling support services are provided free of charge. Because 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.

## THE LEARNING CENTER

The Learning Center is a "drop-in" facility open daily on the Brooklyn campus from 10:00 a.m. to 6:00 p.m. and on the Farmingdale campus from 9:00 a.m. to 5:00 p.m., offering help to students having difficulty in chemistry, computer science, mathematics and physics. It is not a tutoring program. A staff of qualified undergraduate and graduate students assists students who have specific problems with their studies.

Nearly all student problems can be handled by these student helpers. More difficult problems are referred to the director or the course instructor. Students needing regular one-on-one tutoring are referred to the Office of Special Services.

## CAREER SERVICES OFFICE

As its name suggests, the Career Services Office is available to assist students in meeting their varied career needs. Polytechnic students are encouraged to begin taking an early and active role in planning for their career development. For this reason, the goals of the Career Services Office are to assist students in:

- becoming better informed of their career options
- identifying and pursuing their abilities and interests
- providing experiences and services which will allow students the opportunity to apply their skills and academic background in paid and non-paid work assignments
- deciding whether to pursue graduate study or full-time employment
- making a successful transition from the academic setting to the business, government and industrial sectors

Students at every academic level are encouraged to speak with professional staff concerning both their career development and job placement needs. Ongoing developmental career services include: career fairs; career exploration workshops and seminars; and individualized counseling concerning job skills (résumé writing, job search and interviewing techniques) and career decision-making.

Job placement services help students gain valuable work experience in both engineering and non-engineering positions. Full- and part-time job banks, summer job assistance and our extensive recruiting program meet the needs of job-seeking students. The demand for Polytechnic graduates is great, as evidenced by the more than 100 companies that recruit on campus each year. These companies

conduct over 1,000 interviews yearly, resulting in employment for many of our graduates. During 1992, the placement rate for Polytechnic B.S. graduates was 83%.

As the Career Services Office firmly believes that career planning and development is an on-going process, alumni are welcome to use the resources of the office when planning or making career or job changes. In addition to the corporate library, job bank and other reference periodicals and literature, individualized counseling is available on a limited basis.

### COUNSELING SERVICES

At times, students can find themselves dealing with a range of situational or personal roadblocks which may interfere with their ability to succeed academically. The University is committed to assisting students in addressing those concerns in two ways. Free, short-term counseling is available on-site through the Office of Special Services. Typical areas of concern include study habits, adjustment problems, stress management and relationship difficulties.

For in-depth and long-term counseling or psychological evaluation services, referrals to off-site services are made. Fees are charged by these external organizations, with many agencies offering sliding-scale rates to match the ability of the student to pay. In addition, many agencies will accept payments from insurance carriers, if the student's policy covers counseling and evaluation services. Students seeking an off-campus referral can receive assistance from the Department of Student Life or the Office of Special Services.

### NEW STUDENT ORIENTATION

Polytechnic seeks to ease the new student's transition to his or her new environment. We offer a variety of programs designed to orient and welcome new students every semester. These programs include a new student overnight in the Fall,

on-campus new student orientation days every semester, programs for parents of freshmen, and other social activities in addition to the Freshman Seminar—SL101 (see following section).

We encourage every new student to attend all Orientation events. These programs provide a vital link for securing a strong relationship with the Polytechnic environment. For example, in August of every year the new student overnight, which takes place at an off-campus facility, brings together Polytechnic faculty, administration, staff, alumni, upperclass students and new students. This unique interaction allows new students to become familiar with new faces in the Polytechnic community before they begin classes. The event is offered at no additional cost, and is open to all international students in addition to both undergraduate transfer students and freshmen.

### FRESHMAN SEMINAR (SL101)

SL101 is required for all entering freshman with fewer than six transfer credits. It is an extended orientation to the academic and social challenges of higher education, and a preparation for the critical choices and decisions college students must make.

SL101 is designed to introduce freshman students to Polytechnic University and to support their efforts to achieve success in this environment. New academic challenges and responsibilities, new people and situations, new time demands and commitments are among the factors present in the transition to college. This seminar provides students with opportunities to develop new skills and resources which may enhance their chances for success. SL101's educational experience incorporates the richness of resources from both inside and outside the Polytechnic community. The seminar consists of a variety of guest lecturers, small group workshops, faculty presentations and sessions reserved for small group discussion on topics of particular interest to each group. This diversified experience sets the stage for each new freshman at Polytechnic to explore why he or she has chosen Polytechnic and how he or she can get the best out of his or her Polytechnic education.

### Topics covered in the course include:

- Study Skills—(including note taking, test taking, effective reading.)
- Time Management
- University Resources and Support Services
- Campus Involvement and Student Activities
- Effective Library Research Skills
- Career Awareness
- Effective Communication Techniques
- Priorities and Goals
- Health and Wellness (including stress management, and alcohol and drug issues.)

At the end of the seminar, the student will formally declare a major, or confirm a previously declared major.

### UNDERGRADUATE ADVISERS

All undergraduate students are assigned an adviser in their respective major departments. Undecided or undeclared majors are advised by the Department of Student Life. These departmental advisers are available for individual appointments to discuss academic and related matters. A student's adviser must sign all registration, course adjustment, and course withdrawal forms.

In addition to departmental advisers, freshmen are assigned a specially selected freshman adviser, who is there to assist the student in making the transition to Polytechnic. Freshmen initially meet their freshman adviser through the Freshman Seminar (SL101) and are required to meet with their freshman adviser during the first semester at Polytechnic.

### GRADUATE ADVISERS

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

### INTERNATIONAL STUDENTS

All international students and scholars are **REQUIRED** to contact the International Student Adviser in the Department of Student Life immediately upon arrival. Students must bring their immigration documents and passports with them for their initial meeting.

Polytechnic University has enrolled international students in both graduate and undergraduate studies for many years. Students holding visas make up nearly 15% of the Polytechnic population and are an integral part of the university. Faculty and administrators are sensitive to the needs of international students and strive to meet them. Services for international students are coordinated by the International Student Adviser, who is primarily located on the Brooklyn campus. International students on the Long Island campus may contact the International Student Adviser by telephone or go to the Department of Student Life on the Long Island campus for assistance.

Information regarding immigration compliance, housing, health insurance, special events and referrals are available through the International Student Adviser. For further information, consult those sections dealing with graduate and undergraduate admissions.

### HANDICAPPED STUDENTS

Polytechnic fully supports Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act. In this regard, it makes every effort to provide full and barrier-free program accessibility, so that handicapped individuals may fully participate in the life of the university. Handicapped students needing special arrangements or experiencing barriers should contact the Department of Student Life for assistance.

### REQUIRED IMMUNIZATION

New York State recently enacted a law which requires students to show proof of immunity to measles, mumps and rubella. Polytechnic will comply fully with the provisions of this law. All students (graduate and undergraduate), born on or after January 1, 1957, taking six or more credits, must comply with this law.

Immunization status will be checked as part of the registration process. Students who are not in compliance with the law; (1) will be barred from attending class (and will not be entitled to any tuition refund); (2) will not receive grades; and (3) will be denied further registration.

For forms or information on this requirement, or to submit the required proof, please contact the Department of Student Life in Brooklyn or Farmingdale, or the Administration Office in Westchester.

### ALCOHOL AND DRUGS

In conformity with New York State law, Polytechnic prohibits the unlawful possession, manufacture, use or distribution of illicit drugs and alcohol on its property or as part of any of its activities. Violations of this policy will result in disciplinary actions pursuant to the University Code of Conduct. Furthermore, Polytechnic will not protect those who violate these laws, nor will it interfere with law enforcement agencies that may pursue violators of these laws.

Students may not possess, consume or distribute alcohol on University premises or at University-sponsored activities, except in the following circumstances: by students over the age of 21, in their residence hall rooms, unless prohibited by residence hall policy; by students over the age of 21, at a University-sponsored activity where express permission to serve alcohol has been obtained from the Dean of Students.

All student organizations or groups wishing to hold events where alcohol is served must obtain the permission of the Dean of Students or designee, who will be solely responsible for making that decision and applying conditions and obligations to that permission.

### ACCIDENT AND SICKNESS INSURANCE

Currently, all full-time students (graduate and undergraduate) are covered by accident insurance, at no additional charge. Complete health insurance coverage is recommended for all students and is required for international students and students living in residence halls owned or contracted by the University.

Information on the Polytechnic accident insurance (free for all full-time students) and sickness insurance (additional fee) policies is sent annually to full-time students. If you do not receive these materials, or need further information, contact the Department of Student Life. Spouses and dependents of full-time students are eligible for insurance coverage.

Polytechnic does not maintain health facilities on its campuses. In a health emergency, students should contact security and/or the Department of Student Life to arrange for emergency transportation to a hospital.

**GUIDELINES ON STUDENT RELIGIOUS OBSERVANCES**

The faculty of the University has adopted the following guidelines on student religious observances, as recommended by the Commission on Independent Colleges and Universities. The intent of these guidelines is to encourage independent colleges and universities to reasonably accommodate individual students' religious obligations and practices without penalty.

- No student will be expelled or refused admission to the University because he or she is unable to participate in any examination, study or work requirement because of his or her religious obligations and practices.
- The University will accept the responsibility of making available to each student who is absent from school because of his or her religious obligations and practices an equivalent opportunity to make up any examination, study or work requirement which may have been missed because of such absence on any particular day or days.
- The University requires students to notify the instructor in writing, no later than the fifteenth day after the first day of the semester, of each class scheduled for a day on which the student will be absent because of his or her religious obligations and practices.
- In effecting these provisions, the University's administration and faculty agree to exercise the fullest measure of good faith, and agree that no adverse or prejudicial effects should result to any student who avails himself or herself of these guidelines on religious observances.

**STUDENT RETENTION**

As required by the New York State Education Department Higher Education Data System, Polytechnic conducts a yearly cohort survival analysis. This study is

designed to collect data for a group or cohort of first-time, full-time freshman (never attended college before), 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 1992 study was the group of first-time, full-time students who entered as freshmen in the Fall of 1986. Of that entering class, 35.3% received their Bachelor of Science degree within four years; 55.0% graduated within five years; and 59.0% completed their degree within six years.

**ATHLETICS**

For information on intercollegiate and intramural athletics, please refer to the section entitled, "Physical Education and Athletics," featured toward the end of this catalog.

Recreational activities are offered at the Gymnasium located on the Long Island Campus, and at The Eastern Athletic Club located near the Brooklyn Campus (specified hours only). Contact the Department of Physical Education and Athletics for more information.

**CO-CURRICULAR STUDENT ACTIVITIES**

Student activities are an integral part of the educational process. Participation in student activities fosters the development of leadership and interpersonal skills. Polytechnic believes that involvement in student activities broadens the academic experience of students who participate.

**ORGANIZATIONS AND ASSOCIATIONS**

There are more than 50 student organizations, honors societies, and fraternities on the Brooklyn and/or Long Island campuses. Each group is responsible for fulfilling the purposes of the organization as set forth in a constitution or charter. Student organization documents are filed with the appropriate student governing body on the Brooklyn and Long Island campuses.

**STUDENT GOVERNMENT**

The student government is the student voice at Polytechnic. It is responsible for administering student activities fees, social and cultural programming, and other co-curricular activities. There are separate student governing bodies on the Brooklyn and Long Island campuses—the Student Council (Brooklyn) and the Student Government Organization (Long Island). Student government officers are undergraduate students selected annually during campus-wide elections.

**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 chapter meetings, members hear distinguished guest speakers, plan field trips, read professional papers, and work on technical projects.

- Professional and Departmental 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 Electronics Engineers
  - Institute of Industrial Engineers
  - National Society of Black Engineers
  - National Society of Professional Engineers
  - Society of American Military Engineers
  - Society of Automotive Engineers
  - Society of Hispanic Professional Engineers
  - Society for Human Resource Management
  - Society of Physics Students
  - Society of Women Engineers

**HONOR SOCIETIES**

On the basis of their superior academic record and co-curricular achievement, students are selected during their junior and senior years to one of the Polytechnic chapters of a national honorary fraternity. Closely allied to the professional and technical societies, these honorary fraternities encourage and recognize outstanding scholarship and leadership.

## CAMPUS LIFE AND SUPPORTING SERVICES

### *Honor Societies*

Chi Epsilon, civil engineering  
Eta Kappa Nu, electrical engineering  
Omega Chi Epsilon, chemical 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  
Upsilon Pi Epsilon, computing sciences

### **FRATERNITIES**

Polytechnic has four social and service fraternities. One of them owns property in the Brooklyn area, and offers live-in accommodations. The fraternities hold an impressive array of social functions for their own members and provide service to the University community. Fraternities coordinate blood donation drives, annual charity drives, athletic tournaments, parties, and more.

### *Fraternities*

Alpha Phi Omega  
Lambda Chi Alpha  
Omega Phi Alpha  
Tau Delta Phi

### **SOCIAL, CULTURAL, RELIGIOUS, MEDIA AND OTHER ORGANIZATIONS**

There are student organizations at Polytechnic to suit every interest, whether social, intellectual, religious, musical, cultural, or athletic. Many of the organizations have a long and distinguished history.

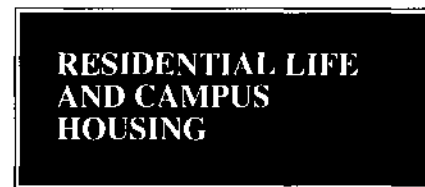
### *Social, Cultural, Religious and Other Organizations*

Asian Student Association  
Association of Latin American Students  
Campus Advance  
Chess Club  
Chinese Student Association  
Conflict Simulation Society  
Demokritos (Greek Club)  
Haitian Student Association  
Hong Kong Student Association  
Indian Pakistani Organization

Indian Student Association  
International Student Association  
Jewish Student Union  
Korean Student Association  
Malaysian Student Association  
Muslim Student Association  
National Association for Rigorous Training Unit  
Pershing Rifles  
Polytechnic Computer Information Systems Group  
Polytechnic Electronics & Robotics Club  
Polytechnic Intersarsity Christian Fellowship  
Programming Advisory Board  
Radio Club  
Resident Student Organization  
Sappers  
Society of Pakistani Engineers  
Society of Russian Scientists  
Stage Band  
Table Tennis Club  
Torah Society  
United Students Association  
Vietnamese Student Association

### **PUBLICATIONS**

Bohican  
(*Long Island campus newspaper*)  
Innovations  
(*Long Island campus yearbook*)  
Polywog  
(*Brooklyn campus yearbook*)  
Reporter  
(*Brooklyn campus newspaper*)



A residential life program is an integral part of college life and can greatly enhance your college experience. Resident students become members of a supportive peer community in an academic environment which offers the opportunity to more fully develop academically and socially. The residential life experience helps students to develop personal responsibility as it supports them in meeting their academic goals. Polytechnic is committed to providing safe and affordable housing for students who are interested in a residential life experience.

Campus housing is available for matriculated, full-time, undergraduate and graduate students. It is not appropriate for married students seeking housing for their families. Inquiries about campus housing should be made to the Student Life office on the appropriate campus.

### **CAMPUS HOUSING AT THE LONG ISLAND CENTER**

There are two residence halls on the Long Island campus, housing a total of 90 students. The East Residence Hall primarily houses upperclassmen in four-person suites with private bedrooms, a common suite area with cooking facilities, and a bathroom. The West Residence Hall primarily houses freshmen in double rooms with common bath/shower facilities. All residents in West Hall are required to subscribe to a meal plan. Both residence halls have coin-operated laundry facilities and recreation areas—East Hall has a game room and West Hall has a large multi-purpose lounge.

### **CAMPUS HOUSING SERVICE AT THE BROOKLYN CENTER**

At the Brooklyn campus, housing is offered to students in cooperation with the Richard L. Conolly Residence Hall at Long Island University, and the Leo J. Pantas Residence Hall at Pratt Institute. Both facilities have trained professional and student staff, who work and live in the residence halls. In addition to providing 24-hour security, both residence halls are well maintained.

**Richard L. Conolly Hall** is just five blocks, and a 10 minute walk, from Polytechnic. It houses undergraduate students; however, graduate students may choose to live at Conolly Hall as well. First-time residents are usually placed in standard double occupancy rooms. A standard 12' x 20' room has two wardrobes, chests of drawers, desks, and beds. Conolly Hall, which houses up to 600 students, is open year-round. All rooms, and most floors, are single-gender. Common bathroom and shower facilities are located on each floor. Where floors are co-ed, separate facilities are provided. The meal plan

is optional. Other facilities within the residence hall include a personal computer laboratory equipped with IBM personal computers; a multi-purpose gameroom with pool table, vending machines, and television. Dining room and coin-operated laundry facilities are conveniently located on the premises.

**Leo J. Pantas Hall** is one and one-half miles—a 15 minute bus ride—from Polytechnic. Pantas Hall is designed to accommodate graduate as well as undergraduate students and houses up to 230 residents. Students live in two- or four-person suites consisting of two bedrooms (10' x 16')—each with its own vestibule (8' x 9') and a bathroom. Bedrooms are furnished with wardrobes, chests of drawers, drafting tables, chairs, and beds. Suites are

single-gender, but floors are co-ed. The meal plan is mandatory. Pantas Hall is open to students during the Fall and Spring semesters. Other features of the hall include a multi-purpose lounge equipped with a television and a warm-up kitchen for social events. The campus dining room and laundry facilities are open seven days a week and a commissary is also available.

### ***CAMPUS HOUSING REQUIREMENTS***

All resident students are required to have a Health Examination Form completed by their physician certifying their good health. Additionally, resident students must have medical insurance coverage.

### ***OFF-CAMPUS HOUSING OPPORTUNITIES***

Students interested in off-campus housing may take advantage of announcements made available through the Off-Campus Housing postings on bulletin boards at each campus.

### **UNIVERSITY CODE OF CONDUCT**

The University Code of Conduct is distributed regularly to all students. This document gives notice of prohibited behavior and outlines the procedures to be followed in the event of a breach of this code. This document is dedicated to the protection and promotion of the academic enterprise.

# ADMISSIONS

The course of studies at Polytechnic is academically rigorous and intellectually challenging; therefore, admission to Polytechnic is highly competitive. Candidates for admission to graduate programs are evaluated by the department to which they apply. Students seeking admission to the undergraduate programs are evaluated by the professional staff of the Office of Admissions according to criteria established in concert with the University's Committee on Admissions.

## GRADUATE

To be eligible for admission as a graduate student, an applicant must hold a bachelor's degree from an institution acceptable to Polytechnic. Attention will be given to listings by the Accreditation Board for Engineering and Technology, the American Chemical Society, the Computer Science Accreditation Board, 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 need to take additional courses for which graduate credit may not be given. (See "Conditional Status.")

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

Graduate admission information can be obtained from the Office of Graduate Admissions, Polytechnic University, 6 Metrotech Center, Brooklyn, New York 11201, (718) 260-3200.

## 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 Graduate Admissions. An application should be supported by letters of recommendation from persons qualified to comment on the applicant's aptitude for graduate study and research, and standardized admission test results where required. 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 student must complete an application for admission by May 1 (fall admission), October 15 (spring admission) or March 1 (summer admission) 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 of all international applicants who have earned a bachelor's degree from an institution in a non-English speaking country and/or speak English as a second language. The Test of Spoken English (TSE) is required of all teaching fellowship applicants from non-English speaking countries.

Certification of ability to meet financial obligations is also required.

## STATUS

Within the full-time and part-time classifications of graduate admission 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 Graduate Admissions.

### Regular Status

A graduate degree or certificate applicant who is adequately prepared to begin the program applied for is assigned regular admission status upon the recommendation of the major department's faculty.

### Conditional Status

A graduate degree or certificate 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 file is lacking documents necessary for academic evaluation may be permitted to register for one semester with provisional status. The applicant must provide all required admission documents to the Office of Graduate Admissions before the sixth week of the semester. If the applicant is not accepted for admission, the semester can be completed or a withdrawal 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 admission status. A formal application for admission may or may not have been filed with the

Office of Graduate Admissions. 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 may be applied 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. Special (graduate) students must hold a bachelor's degree from an institution acceptable to Polytechnic.

**Readmission**

Part-time students who last attended Polytechnic within a three-year period before the semester in which they seek to be readmitted need no formal readmission, and are automatically permitted to register. Part-time students who have not attended within the past 3 years must file an application for readmission which is available from the Admissions Office.

Full-time students who desire to interrupt their studies may request a leave of absence for a specified period of time, usually not exceeding one year. Such requests, when approved by the V.P. for Research and Advanced Programs, will constitute assurance of readmission to the degree program from which the leave was taken. When the period of absence exceeds the approved leave of absence, the student must apply for readmission.

**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 counted towards the master's degree program, and the grades are recorded on the graduate transcript.

**UNDERGRADUATE**

**THE APPLICATION PROCESS**

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

**BROOKLYN/FARMINGDALE**

Polytechnic University Six Metrotech Center Brooklyn, NY 11201 (718) 260-3100	Polytechnic University Route 110 Farmingdale, NY 11735 (516) 755-4200
--	--

Undergraduate applicants should complete the application for admissions and forward it to the Office of Admissions with either the non-refundable application fee or a fee waiver request form. Applicants should request that their secondary school and/or college forward official copies of transcripts to the Polytechnic Office of Admissions. All freshmen applicants and transfer applicants with less than two complete years of college are required to submit test scores of the Scholastic Aptitude Test (SAT) or the American College Testing Program (ACT).

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 time-table:

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

Candidates for freshman admission to the fall term who submit their applications and all of their documents before January 15 will receive a decision by February 1. Freshman candidates for the fall term who apply after February 1 will receive an admission decision within two weeks after submission of all documents. Admission of fall freshman 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 offi-

cial records, together with notarized translations, must also be received by the dates below. (See "Admission as an International Student.")

If accepted for admission, the applicant should submit an enrollment deposit of \$250.00 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 summer or fall semester, nor after January 1 for the spring semester.

Applicants accepted 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 ADMISSION PLAN**

On occasion, Polytechnic offers early admission to outstanding high school juniors. Programs can be arranged so that these students simultaneously satisfy high school requirements while completing their freshmen year of college. Candidates for this program must complete the required 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.

**ADMISSION AS A FRESHMAN**

**Examinations**

Applicants for admission as freshmen are required to take the Scholastic Aptitude Test (SAT). The American College Testing Program may be substituted for the College Board examinations. Students who are admitted to Polytechnic and plan on enrolling will be required to take two placement examinations prior to opening day of classes.

The preferred secondary school course of study is:

<b>(course)</b>	<b>(years)</b>
English	4
Foreign Language	2
Science	4
<i>(Physics and chemistry strongly recommended)</i>	
Mathematics	4
<i>(elementary algebra, geometry, intermediate algebra, trigonometry)</i>	
Social Studies	3
Electives	2
<i>(technical courses such as pre-calculus, calculus, advanced laboratory science, computer science, etc., preferred)</i>	

## ADMISSIONS

This course of study is only a directive, not an absolute requirement. The primary concern of the members of the Committee on Admissions is to determine an applicant's potential for success at the University.

### *Interviews and Campus Tours*

Prospective students are strongly encouraged to visit the campus of their choice. Arrangements can be made by calling the Office of Admissions at the appropriate 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.

### *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, the French Baccalaureate or General Certificate Exam "A" level.

Specific requirements for administering college credit, for both the Advanced Placement and the International Baccalaureate Exam, French Baccalaureate or General Certificate Exam "A" levels, etc., vary from department to department. Students will be required to take a placement exam in order to determine their freshman course selection.

### **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 New York State guidelines which consider family size, family members who are students and family income.

Freshmen entering HEOP are required to take six weeks of remedial work during the summer prior to beginning the freshman year, to make up prerequisites and courses in which weakness is shown.

Transfer students may enter HEOP provided there is space available. Only students coming from similar programs approved by the HEOP central office are eligible to transfer into HEOP. HEOP is available at

the Brooklyn campus only. For further information, contact the Director of HEOP at (718) 260-3370.

### **ADMISSION AS AN INTERNATIONAL STUDENT**

International students must meet four basic criteria for admission to Polytechnic and receipt of a valid I-20 or IAP-66:

- Academic credentials (grades, certificates, degrees) must be assessed as suitable for entry to the appropriate University program.
- The Test of English as a Foreign Language (TOEFL) is required of all students whose native language is not English.
- The Polytechnic Declaration and Certification of Finances (Affidavit of support) must be duly signed and accompanied by a bank statement signed by a bank official.
- Students holding F-1 or J-1 visas must enroll as full-time students.

If transfer credit is desired, candidates must include catalog or syllabus descriptions of courses completed. English translation must be provided where necessary. 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 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 SAT or ACT 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 for transfer credit.

Transfer students accepted under the Undergraduate Waiver of Admissions Credentials Plan must submit official transcripts within 30 days of their first registration, or further registration will be prohibited.

Transfer credits will be evaluated prior to the end of the first semester the transfer student is enrolled at the University. Core courses are evaluated by the Office of Admissions. Upper level courses are evaluated by individual major academic departments.

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. Transfer credit will not be considered for any course with less than a "C" grade. Any student who completes a course in residence at Polytechnic for which transfer credit has already been granted will automatically forfeit the transfer credit for that course.

In certain instances, course requirements may be waived for students who demonstrate sufficient knowledge of a specific course content through either oral or written examinations given by the appropriate department. 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 placement examinations.

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

### **ADMISSION AS A PART-TIME STUDENT**

Students seeking a bachelor's degree may enroll on a part-time basis (11 credits or less) at the Brooklyn or Long Island Campus taking day and/or evening courses. Please see sections on individual majors to determine whether part-time evening studies are available. Part-time undergraduate students should be aware that it is no longer possible to take a complete bachelor's degree program by attending only evening courses. Some daytime attendance is required.

Regulations concerning subject requirements and admissions procedures are given in the section "Admission as a Freshman."

Following notification of acceptance, students will be notified when to contact the adviser of their major department. In some cases, this may be accomplished during registration.

### ***SPECIAL AND VISITING STUDENTS***

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 be completed during registration. A special non-degree status may satisfy the needs 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 applied to a degree program. Some courses, however, may be applied to a degree program with the approval of a departmental adviser. Students may enroll in up to 9 credits as a special student before formal admission is required.

### ***COLLEGE PREVIEW***

Through Polytechnic's College Preview Program, students may earn college credit during their senior year of high school by enrolling in approved undergraduate courses at Polytechnic. Courses are offered to College Preview students at substantially reduced tuition.

### ***READMISSION***

Polytechnic students who have not been in attendance for one semester or more are required to apply for readmission. Students applying for readmission will be expected to state their reasons for leaving the University, and are expected to explain why they desire to return. Official transcripts of college-level courses taken during this period of absence from Polytechnic must be submitted with the application for readmission.

# FINANCIAL AID

## GRADUATE

### **GRADUATE FELLOWSHIPS AND ASSISTANTSHIPS**

Fellowships and assistantships are available for advanced study leading to the master's, engineer, or doctor's degree in engineering and science disciplines. 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 for the academic year (less any other entitlement) is remitted.

#### **Teaching Fellowships**

Fellows are full-time graduate students who participate half-time throughout the academic year in teaching assignments. Tuition for the academic year (less any other entitlement) 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.

### **MAYOR'S GRADUATE SCHOLARSHIP PROGRAM**

In an effort to strengthen the relationship between the City of New York and Polytechnic University, the Mayor's Graduate Scholarship Program provides scholarships for part-time graduate students who are full-time employees of the City of New York. Half-tuition scholarships are awarded each year to students studying in the fields of management and engineering. Scholarships are renewed annually until the courses of study for the MS degree is completed provided the student maintains an overall "B" average.

To be considered for a scholarship a student must submit an application for graduate admission to Polytechnic University and be accepted. In addition, students must complete the Mayor's Graduate Scholarship Application, available from the New York City Department of Personnel. To be considered for a scholarship, all applications must be submitted by May 31. Scholarship recipients are notified of the award after the first week in July.

### **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-half for graduate courses, taken at any campus. Degree candidates and special students are eligible.

Written verification of employment as a full-time high school or college teacher, signed by the department head and an officer of the applicant's institution, must be submitted at 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 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.

### **GRADUATE TUITION ASSISTANCE PROGRAM (TAP)**

Graduate TAP is an entitlement/ grant program administered annually by the New York State Higher Education Services Corporation (NYSHESC) for New York State resident students.

Eligible applicants must (1) be New York State residents, U.S. citizens or eligible non-citizens, (2) be enrolled full-time as a matriculated student and (3) meet the scheduled income requirements listed below:

- If financially dependent on parents OR if financially independent of parents and are married or have tax dependents, have a New York State Net Taxable Income of less than \$20,000.
- If financially independent of parents and single with no tax dependents, have a New York State Net Taxable income of less than \$5667.

Using the TAP Adjustment Supplement, the Net Taxable Income is divided by the total number of family members in full-time attendance.

- The maximum annual award is \$1200 and is reduced according to family income levels. No award is less than \$100 per year. TAP may be received for 8 semesters of graduate studies.
- Applicants must apply annually to NYSHESC using the TAP Student Payment Application. Applications are available in the Office of Financial Aid and must be submitted prior to the May 1 deadline during the award year. TAP recipients will receive an award certificate from NYSHESC which is to be presented to the Bursar's office for payment/deferment.

## **POLYTECHNIC 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 a U.S. citizen. More information can be obtained from the Schedule of Classes or the Office of Financial Aid.

### **FEDERAL STAFFORD STUDENT LOAN PROGRAM**

Graduate students may apply for a Federal Stafford Student Loan for \$8,500 per academic year for periods of enrollment beginning on or after 10/1/93. The interest rate is an annual variable rate based on a 91-day T-Bill plus 3.1% with a cap of 9% (Current rate as of 7/1/93 is 6.22%.) To be eligible for a Stafford Student Loan, students must (1) be United States citizens or eligible non-citizens, (2) be enrolled for at least six credits per semester and matriculated, (3) be making satisfactory academic progress and (4) demonstrate financial need. All applicants must complete a Financial Aid Form (FAF) and a Free Application for Federal Student Aid (FAFSA) to determine need. All interest and principle payments are deferred as long as student is enrolled for at least six credits per semester. Repayment begins six months after graduating or withdrawal from school. Immediate repayment is required if the borrower is enrolled less than half-time. Loan applications are available at lending institutions or the Polytechnic Financial Aid Office.

### **FEDERAL UNSUBSIDIZED STAFFORD LOAN**

This loan is open to students who do not qualify for the above, unsubsidized Federal Stafford Loan. The same terms, conditions, annual borrowing limits, and interest rates apply as Federal Stafford Loans. The one exception being that the borrower is responsible for interest that accrues while they are enrolled in school and during the 6 month grace period. Loan applications are available at lending institutions or the Polytechnic Financial Aid Office.

## **FEDERAL SUPPLEMENTAL LOANS FOR STUDENTS**

All graduate students are eligible for the Federal Supplement Loan to assist with the costs of education. The annual loan limit is \$10,000 for periods of enrollment beginning on or after 7/1/93. The interest rate is an annual variable rate based on a 52-week T-Bill plus 3.1% with a cap of 11% (Current rate as of 7/1/93 is 6.64%.) To be eligible, students must (1) be United States citizens or eligible non-citizens, (2) be enrolled for at least six credits per semester, (3) be making satisfactory academic progress and (4) Supplemental Loan funds in combination with other financial assistance cannot exceed the cost of education.

Loan applications are available at lending institutions or the Polytechnic Financial Aid Office.

## **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 including student income, family income, Polytechnic University grants, and independent and government funds.

All financial aid is limited to the need of the student 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, as follows:

**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 rates with extended repayment terms.

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

About 85% of Polytechnic's undergraduate students receive aid in combinations of scholarships, grants, campus jobs, Federal Perkins Loan (NDSL), and Federal Stafford Loans (formerly GSL).

### **To Apply for Financial Aid:**

Incoming freshmen should file the complete Financial Aid Form (FAF) and the Free Application for Federal Student Aid (FAFSA) with the College Scholarship Service, Princeton, New Jersey, during the month of January. (Later applications will be considered on a rolling basis as funds are available.)

Transfer students should file the FAF and FAFSA by May 1, or as soon as possible thereafter, and request a financial aid transcript from the transferring institution to be sent to the Financial Aid Office at Polytechnic University by June 1.

### **To Renew Financial Aid:**

Continuing students should obtain Financial Aid packets from the Office of Financial Aid beginning March 1.

Students should file the Polytechnic Financial Aid Application and Verification Supplement with the Office of Financial Aid by April 15. A copy of the parents' and/or the student's federal and state tax returns with all required schedules, along with documentation of all untaxed income must accompany this application. Late or incomplete application material will result in a reduction or forfeiture of institutionally administered financial aid.

## **FEDERAL CAMPUS-BASED PROGRAMS**

To be eligible for one of the federal campus-based programs, applicants must show need, be enrolled at least half-time (the equivalent of at least 6 credits per semester), and be either U.S. citizens or eligible non-citizens.

To apply for one of these programs, students must have been accepted to Polytechnic and have filed the FAF and FAFSA with the College Scholarship Service. Awards are determined by Polytechnic's Financial Aid Office.

## FINANCIAL AID

To continue to receive an award, a student must make satisfactory academic progress, provide the Financial Aid Office with all requested documents and report any changes in their financial situation.

### *Federal Supplemental Education Opportunity Grant (SEOG)*

The SEOG is awarded to under-graduates with exceptional financial need. At Polytechnic, qualified applicants receive between \$300 and \$1,500 per year. Usually, the award will continue to be offered for four years, but is based upon financial need.

### *Federal Perkins Loans (formerly National Defense Student Loans, NDSL)*

The Perkins Loan is a low interest (5%) loan. The loans are made available through the Office of Financial Aid. Perkins loans are awarded as part of the financial aid package, with a range of \$1000 to \$1500 per academic year. Perkins loans are limited to \$4500 for the first two years of college study. Total undergraduate Perkins loans may not exceed \$9000. Under the Perkins Loan, the maximum amount students may borrow is \$18,000 for all college-related expenses, for all their years of undergraduate, graduate and professional study. Upon approval of the loan, the student signs an "Affidavit of Educational Purpose" and a promissory note.

The repayment period and the interest for the Perkins Loan do not begin until nine months after students complete their studies. In an exit interview, the student agrees to repayment, monthly, bi-monthly or quarterly. Interest of 5% per year is charged during the repayment period. Repayment begins 9 months after termination of full- or half-time study and may continue over a 10-year period. Terms for deferment of payment and cancellation of the loan may be found in the Perkins Loan Promissory Note.

### *Federal College Work-Study Programs*

The College Work-Study Program provides part-time jobs for undergraduate and graduate students. Earnings from these jobs help students meet college-related expenses. Employment eligibility is determined by the Financial Aid Office. Work arrangements are made through the Career Services Office.

At Polytechnic, the maximum College Work-Study award is \$1000 per academic year. Jobs are arranged on-campus. Most assignments average 15 hours per week, and the work schedule is adjusted to the needs

of the student and the employer. The starting rate of pay is usually \$1.50 per hour, but varies depending on the position. Students are paid bi-weekly.

## **FEDERAL AND STATE SPONSORED PROGRAMS**

### *Federal PELL Grants*

The PELL Grant is a need-based grant program. Awards are determined by the U.S. Department of Education according to an "eligibility index" and by the level of appropriations available. Grants are for study leading to a first bachelor's degree and are usually the first component of all financial aid packages. Currently, awards may not exceed 60% of the cost of education, or \$2300, whichever is less.

To be eligible, students must be U.S. citizens or permanent residents, be making satisfactory academic progress, be enrolled at least half-time (the equivalent of six credits per semester), and meet federal income requirements.

If students received a PELL Grant for the first time in 1987-88, or thereafter, the PELL Grant eligibility will be limited to five full years of study.

Students may apply for the PELL Grant by completing the FAF and FAFSA through the College Scholarship Service. Students applying for financial aid at Polytechnic (including the Stafford Loan) are required to apply for a PELL Grant. Students must file an application by May 1 for the current academic year.

### *Tuition Assistance Program*

The Tuition Assistance Program (TAP) attempts to minimize the difference in cost normally found between New York's Public and Independent colleges so that students are able to make their choice based on program characteristics alone and not the difference in cost. There is no competition for TAP support.

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.)

To be eligible for a TAP award, students must (1) be New York State residents and U.S. citizens or permanent residents, (2) be enrolled full-time at an approved New York State post-secondary institution, (3) be charged tuition (exclusive of fees) of \$350 per year or more, (4) meet income requirements established by New

York State, and (5) file by the required deadline, May 1 for the current academic year.

To apply for the TAP award, students should check the appropriate box on the FAF, or students may obtain an application from their high school guidance counselor, Polytechnic Financial Aid Office, or the New York State Higher Education Services Corporation, 99 Washington Avenue, Albany, New York 12255. There is no need to fill out a separate TAP application if a student has filed a New York State Financial Aid Form.

If Polytechnic University's name does not appear on the TAP certificate, a TAP Change Form must be filled out and submitted to NYSHESC. These forms are available in the Financial Aid Office at either the Brooklyn or Long Island campus.

To continue to receive TAP benefits, students must demonstrate satisfactory academic progress. Standards of satisfactory progress are listed in the Academic Policies section of this catalog and are available in the Financial Aid Office. Students may apply for a one-time waiver of academic progress requirements; however, waivers are granted only under extraordinary circumstances. Additional information is available from the Financial Aid Office.

### *Aid for Part-Time Study (APTS)*

The Aid for Part-Time Study program is intended to provide State Grants to less than full-time students.

To be considered for an award, a student must (1) be working toward an undergraduate degree as a part-time student, (2) be in good academic standing, (3) be a resident of New York State, (4) be either a U.S. citizen, permanent resident alien, or refugee, (5) not have used up TAP or other New York State student financial aid eligibility for full-time study, and qualify under the New York State mandated income requirements.

To apply for APTS, student should obtain an application from the Financial Aid Office, and return it as soon as possible to the Financial Aid Office. Students must apply annually. Applications should be filed no later than the second week of classes for the current semester.

### *Vietnam Veterans Tuition Awards Supplement (VVTA)*

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 of entry into service and resumption of residency by

September 1, 1988; (2) have served in the U.S. Armed Forces in Indochina between January 1, 1963 and May 1, 1975; (3) be honorably 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 the Tuition Assistance Program (TAP) and Pell Grant awards. There are no income restrictions connected with this program.

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 specifically require 5 years for full-time study and double the amount of time for part-time study.

To apply, students should obtain applications and other materials available at the Financial Aid Office, any Veterans Office, or by writing to the New York State Higher Education Services Corporation, VVTA, Albany, NY 12255. Applications for the Vietnam Veterans Tuition Award Supplement must be made by May 1, 1992 by part-time students. Full-time students must apply by submitting both Vietnam Veterans Tuition Supplements and the Student Payment Applications (TAP Application) by May 1, 1992.

To continue to receive the VVTA, students must reapply each year.

#### ***Higher Education Opportunity Program (HEOP)***

HEOP is a New York State, and Polytechnic sponsored program for entering freshmen who meet special academic and economic criteria. All inquiries are handled directly through the HEOP Office. Consult the Admissions section of this catalog for more information.

### **POLYTECHNIC UNIVERSITY SCHOLARSHIPS AND GRANTS**

Polytechnic has a strong history of recognizing the scholastic achievements of applicants with outstanding academic credentials. Such awards are based on need, academic achievement and recommendation.

Polytechnic Scholarships are awarded to freshmen and transfer applicants with strong academic backgrounds with full-time schedules (12 credit hours per semester). Awards are determined through demonstrated financial need and merit. Students apply directly to the Financial Aid Office using the FAF. Awards range up to full-tuition. Continuance of the awards demands upon the maintenance of a 2.5 or 3.0 cumulative grade point average (depending on the award) and application to the PELL and TAP programs.

The following scholarships are awarded to freshmen and transfer applicants with strong academic backgrounds regardless of need selected from among the applicant pool.

#### ***Board of Trustee Scholarships***

These scholarships are awarded to academically superior freshmen. Amounts of the scholarships are equal to full tuition, less any outside aid for which students are eligible. Continuance of the scholarships is based on maintaining a 3.0 cumulative grade point average and application to the PELL and TAP programs. (This award does not cover graduate study.)

#### ***Geiger/Fialkov Scholarships***

Awarded to superior freshmen majoring in Engineering or Computer Science. The amounts of the scholarship are equal to full 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. (This award is intended for undergraduate study alone.)

#### ***Dean of Engineering Scholarships***

Each year, the Dean of Engineering awards one \$9000/yr scholarship to a student with superior academic credentials in each of the following engineering disciplines: aerospace engineering, chemical engineering, civil engineering, computer science, electrical engineering, industrial engineering, mechanical engineering, and metallurgical engineering.

Continuance of the scholarship is based upon maintenance of a 2.5 cumulative grade-point average and application to the PELL and TAP programs. A separate application form available from the Admission's Office must be filed for these scholarships.

#### ***Principal's Scholarship***

All high-school principals in the New York metropolitan region are invited to nominate one of their outstanding graduates for an \$9000/yr scholarship award. Recipients are selected from among nominees by a committee of Polytechnic staff and/or faculty. Continuance of the award is based upon maintenance of a 2.5 cumulative grade-point average and application to the PELL and TAP programs. Application forms are available in the student's high school.

#### ***PROMISE Scholarships***

PROMISE Scholarships in varying amounts based upon both need and scholastic achievement may be offered to students who have participated in programs of the Center for Youth in Engineering and Science (YES) while in high school, or other graduates of participating high schools. No award may be greater than the amount of tuition less any other aid for which students may be eligible. Depending upon the amount of award, continuance is based upon maintenance of a 3.0 or 2.5 cumulative grade-point average and application for PELL and TAP programs. No separate application for these scholarships is required.

#### ***Outstanding Transfer Scholarship***

Awarded to superior transfer students with a 3.0 GPA and 60 accumulated transfer credits. The award amounts vary depending upon the GPA of the student. Continuance of the award is based upon maintenance of a 2.5 cumulative GPA, full-time enrollment and application for PELL and TAP programs. No separate application is required.

#### ***Outstanding Achievement Scholarships***

These are awarded to full-time, continuing students (sophomore, junior and senior) with a cumulative grade point average of 3.5 or higher. These scholarships are designed to acknowledge academic achievement for students who did not receive an academic scholarship at the time of entering the university. Applications are made directly to the Financial Aid Office. Minimum awards are \$500.

## FINANCIAL AID

### *Polytechnic Grants*

Polytechnic grants are available to needy students on a limited basis. Students apply directly to the Financial Aid Office by completing a Financial Aid Form (FAF), a Polytechnic Financial Aid Application and Verification Supplement, and by submitting all necessary income documentation.

### **NATIONAL ACTION COUNCIL FOR MINORITIES IN ENGINEERING (NACME) GRANTS**

These are awarded to minority (Black, Hispanic, Native American) students with strong academic backgrounds who demonstrate financial need. Awards are determined by the Financial Aid Office after students begin classes and range up to \$2,500. Maintenance is based upon a 2.5 cumulative grade point average.

### **MINORITY SCHOLARS PROGRAM**

Polytechnic Cooperative Education Minority Scholarships are awarded to superior minority students who participate in the Co-op Program. Newly admitted undergraduate students and students who are enrolled in or have completed at least one co-op course are eligible. Application is made directly to the Cooperative Education Office.

The amount of the scholarships are equal to tuition less any outside aid for which the students are eligible. Continuation of the award is based on maintaining a 2.5 cumulative grade point average and continuing participation in the co-op program.

### **POLYTECHNIC NATIONAL SOCIETY OF PROFESSIONAL ENGINEERS SCHOLARSHIP (NSPE)**

The scholarships are awarded to academically superior freshmen majoring in Engineering. Awards are determined by NSPE and range up to \$1,500. Maintenance is based on a 2.5 cumulative grade point average.

### **CORPORATE AND INDIVIDUALLY SPONSORED SCHOLARSHIPS**

Many of our Polytechnic Scholarships come to us through the generosity of sponsors. Students will be notified if their particular scholarship is corporate or individually donated. Students should thank them for their support.

A list of our current scholarships follows:

The Ralph Abrams Scholarship  
The Benjamin Adler Memorial Scholarship  
The Sidney G. Albert Scholarship  
The Alumni Scholarship  
The Paul C. Bauerle Memorial Scholarship  
Joseph Bommarito Scholarship  
The L.F. Case Foundation Scholarship  
The J.B. Chittenden Scholarship  
The Arthur Clapp Scholarship  
The Samuel & Grace B. Cohen Scholarship  
Crompton and Knowles Chemical Engineering Scholarship  
The DeWitt Scholarship  
The Aaron and Simcha Dubitzky Scholarship  
The W.E. Duryea Scholarship  
The A.S. Dwight Scholarship  
The L.W. Fay Scholarship  
The Polytechnic Fellows Scholarship  
The J. Robert Fisher Scholarship  
The Geiger/Fialkov Scholarship  
Kay & John Giba Scholarship  
The Alex Gruenwald Scholarship  
The Alfred Helwig Scholarship  
The William Randolph Hearst Scholarship  
National Satellite Services Inc. Scholarship  
The E.M. Jabara Scholarship  
Jephson Educational Trust Scholarship  
The Jacob Kaplan Scholarship  
The Eugene R. Kulka Scholarship  
The John F. Kunc Scholarship  
The Litton Industries Scholarship  
The Lyons Scholarship  
The P.R. Mallory Memorial Scholarship  
The Matinicoc Scholarship  
The Raymond Mauro Scholarship  
The Steven J. Meoli Memorial Scholarship  
The NSC-Essie Mitchell Scholarship  
The Colonel Frank Mott Scholarships  
The William Nichols Scholarships  
The Nippon Electric Scholarships

Stanley Nisenson Memorial Scholarship  
The Nordheimer Scholarship  
Radio Club Scholarship  
The Dr. Julian R. Reussenberg Memorial Scholarship  
CA Rieh - Consultants, Inc. Scholarship  
The Julian Rogoff Scholarship  
The Nicholas and Angelica Romanelli Scholarship  
The Myron Rosenthal Scholarship  
The Samuel Ruben Scholarships  
The Schmidt Memorial Scholarship  
The Silleck Family Scholarship  
The Frank R. & Emily E. Stammer Scholarships  
William Stolze Scholarship Fund  
The Solon Summerfield Foundation Endowment  
The Arnold Thompson Scholarship  
Michael Tuch Foundation, Incorporated Scholarship  
The Ernst & Sonya Weber Scholarship  
The Warren & Mary Ann Winsche Memorial Scholarship  
The Unisys Scholarship

### **OTHER OPPORTUNITIES**

#### **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 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 \$1000 for each year the scholarship is in effect.

Air Force ROTC scholarships are available to qualified applicants in both 2- and 4-year programs. Scholarships are based on merit and pay for tuition, books, laboratory and incidental fees, plus a \$100 monthly nontaxable allowance.

#### **Veterans Administration (VA) Educational Benefits**

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

To apply, students should obtain applications available at all VA offices, active duty stations and American embassies as well as the Office of the Registrar. Completed forms should be submitted to the Registrar. A "Summary of Veteran's Benefits" booklet is available from the Registrar.

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.

Students requesting VA education benefits should notify the Office of the Registrar each semester after completing registration. Students must report interrupted attendance or termination of study. Details of Polytechnic's requirements are given to all applicants. Questions concerning veterans benefits or paperwork should be directed to the Registrar's Office either in person, by telephone, or by completing a request for Veteran's Benefits Form.

**Cooperative Education Program (CO-OP)**

Co-op is an alternative means of financing education by combining alternate semesters of outside employment and school attendance.

All inquiries are handled through the Cooperative Education Office.

**Grant Aid To Non-New York State Residents**

Some state aid programs frequently require that awarded funds be used within the state. Others sometimes allow funds to be used out of state. Contact the following agencies for more financial aid information if you are a resident of Pennsylvania, Rhode Island, Vermont or Washington, D.C.

Pennsylvania Higher Education Assistance Agency  
Education Building  
Harrisburg, PA 17126

Office of Scholarships  
Rhode Island Department of Education  
199 Promenade Street  
Providence, RI 02908

Vermont Student Assistance Corporation  
156 College Street  
Burlington, VT 05401

Washington, DC, Grant Program Educational Assistance Office  
1329 E. Street NW  
Room 1050  
Washington, DC 20004

**LOAN PROGRAMS**

Refer to section describing Federal campus-based programs.

**Federal Stafford Loan Program (formerly GSL)**

The Stafford Loan Program gives students the opportunity to borrow money from a local lending institution to help them meet the costs of college or vocational school training. Students may borrow this money at a low interest rate and will not have to begin repayment of their loans as long as they meet the program's academic requirements or until six months after they graduate or withdraw from school.

To be eligible for a Stafford Loan, students must (1) be a United States citizen or eligible non-citizens, (2) be enrolled for at least six credits per semester and matriculated, (3) be making satisfactory academic progress and (4) demonstrate financial need. All applicants must complete a Financial Aid Form and the Free Application for Federal Student Aid to determine financial need and eligibility for a PELL Grant.

Effective 7/1/93, academic year loan limits are \$2625 for freshmen, \$3500 for sophomores, and \$5500 for juniors, seniors and 5th year undergraduates. The interest rate is an annual variable rate based on a 91-day T-Bill plus 3.1% with a cap of 9% (Current rate as of 7/1/93 is 6.22%.)

Students with more than \$5,000 in loans (Stafford, Perkins, Supplemental Student Loan) can consolidate their loans into one repayment package with a 9 percent interest rate, or a weighted average of the rates

on the loans consolidated. Repayment is extended up to 25 years depending on the aggregate amount borrowed. Lenders can offer a graduated or income-sensitive repayment option.

To apply, obtain Stafford applications from participating lending institutions or the Polytechnic Financial Aid Office. In addition, all students, (undergraduate and graduate) must have on file the Financial Aid Form (FAF), the Free Application for Federal Student Aid (FAFSA), the Polytechnic Financial Aid Application and Verification Supplement, and all necessary income documentation. All transfer students must request financial aid transcripts from all previously attended institutions be sent to the Financial Aid Office at Polytechnic University. All new borrowers must complete an entrance interview in the Financial Aid Office prior to endorsement of loan checks. Eligible applicants will be certified and forwarded to the lender indicated and guarantee agency. To ensure that credit for approved Stafford's will be given in lieu of payment at registration, Stafford applications should be submitted to the Office of Financial Aid no less than eight (8) weeks prior to registration.

After graduating, withdrawing from school, or dropping to less than half-time study, the student borrower must see his or her lender and make formal arrangements for repayment of loan and must also attend an Exit Interview in the Financial Aid office. The borrower must actually begin repayment of the loan in the sixth month after graduating or withdrawal from school. Immediate repayment of a loan is required if the borrower does not enroll in school.

A student will be required to repay the total amount borrowed and all interest on the declining balance in accordance with the following regulations.

1. The minimum monthly installment will be \$50 plus interest. (The monthly installment is determined by the amount borrowed).
2. The maximum repayment period for the whole of the loan is 10 years.
3. Repayment of part or all of the loan may be made in advance at any time without penalty.
4. The maximum period of a loan, from the date of the original note, may not exceed 15 years on all loans guaranteed after November 3, 1965, except in cases of authorized deferment (not to exceed three years) while student is a member

## FINANCIAL AID

of the Armed Forces or a volunteer under Title VIII of the Economic Opportunity Act of 1964.

The length of the payment period depends upon the date the promissory note matures as well as the total amount borrowed. A student borrower may be permitted to make payments of less than \$50 per month under unusual and extenuating circumstances. Request for such forbearance must be made to the lender.

### *Federal Unsubsidized Stafford Loan*

This loan is open to students who do not qualify for the above, subsidized Federal Stafford Loan. The same terms, conditions, annual borrowing limits, and interest rates apply as Federal Stafford Loans. The one exception being that the borrower is responsible for interest that accrues while they are enrolled in school and during the 6 month grace period. Loan applications are available at lending institutions or the Polytechnic Financial Aid Office.

### *Federal Supplemental Loans for Students*

All students, except dependent undergraduates, are eligible for the Supplemental Loan program. Effective 7/1/93, annual loan limits are \$4000 for freshmen and sophomores, and \$5000 for juniors, seniors and 5th year undergraduates. The aggregate borrowing amount is \$23,000. The interest rate is an annual variable rate based on a 52-week T-Bill plus 3.1% with a cap of 11%. (Current rate as of 7/1/93 is 6.64% .).

These loans can be used to cover the expected family contribution required in determining need in other financial aid programs. Supplemental loans in combination with other financial assistance cannot exceed the cost of education.

To apply, obtain SLS applications from participating lending institutions or the Polytechnic Financial Aid Office. All students must complete the Financial Aid Form (FAF), the Polytechnic Financial Aid Application and Verification Supplement, and submit all necessary income documentation. Completed applications should be submitted to the Financial Aid Office no less than eight weeks prior to registration for any given academic period. Certified applications are forwarded to the student's lender and guarantee agency.

### *Supplemental Loans for Parents*

Parents may borrow up to full tuition per year for each financially dependent student. A Financial Aid Form (FAF) is not required. However, the Parent Loan combination with other financial assistance cannot exceed the total cost of education. Repayment begins within 60 days from the date you receive the loan. The maximum repayment period is 10 years.

### *Supplemental Higher Education Loan Financing Program (SHELF)*

New York State sponsored, SHELF is a Polytechnic administered program that does not require New York State residency. This program is available to undergraduate, graduate and professional students attending Polytechnic at least half-time. A credit evaluation is necessary and the loan generally will be based on the credit of the parents or co-signer. Many students from families unable to qualify for other financial aid programs may be able to participate in SHELF.

### *Polytechnic University-Sponsored Loan*

Polytechnic sponsored loans are available to both incoming and continuing students based on financial need and the availability of funds. Students are considered for Poly Loans when they apply for Financial Aid using the Financial Aid Form (FAF). Students are generally awarded between \$1000 - \$2000 per academic year. The current interest rate is 7%. Repayment begins after graduation or when the student withdraws from school.

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

## **OTHER RESOURCES**

The Office of Financial Aid has summarized details of several plans currently employed by families to help meet college costs. Students should inquire in the Financial Aid Office for information concerning these programs, the companies that sponsor these programs, and the necessary application procedures.

## **TEN/TWELVE-MONTH PAYMENT PLANS**

University or external payment plans allow students and their families to finance fixed educational expenses over a 10/12-month period with no interest or finance charges. Participating families, make their first payment by May or June preceding the academic year in which it will be utilized.

## **HOME EQUITY LOAN/HOME EQUITY LINE OF CREDIT**

Many parents are pleasantly surprised to discover the resource value of the equity in their homes or apartments. Currently, many lenders offer loans or lines of credit that enable families to put this significant asset to work in financing a college education. Those wishing to pursue this option are encouraged to contact a local lender.

## **OTHER OPPORTUNITIES**

There are some scholarship programs, usually directed by local and civic organizations, which are not based on need. High school guidance offices are the best source of information. Also, parents' places of employment sometimes sponsor programs for employees' children. These employer benefits are often full- or half-time tuition and sometimes merit/need based.

## **IMPORTANT FINANCIAL AID POLICIES**

- To be eligible to receive financial aid, students must be enrolled at least six credits per semester. All Polytechnic Scholarships, Polytechnic Grants, and TAP awards, however, require students to be full-time to qualify.
- Financial Aid applicants (including Stafford Loan applicants) are expected to apply for a Pell Grant and, in the case of New York residents, for the Tuition Assistance Program. Polytechnic scholarships and Polytechnic grants, in combination with Pell Grant and TAP awards, may not exceed tuition.
- Although at Polytechnic the Admissions and Financial Aid Offices are associated, admissions decisions are not affected by financial need. Academic evaluations of a student's qualifications are made without the 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 student 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.
- Standards of achievement for scholarship maintenance are established each semester. Students are reviewed after 2 consecutive semesters. Students who fall below the established criteria will be given one semester of grace to restore their GPA. If they are not successful the scholarship will be revoked. It will be reinstated when the student is successful. Scholarships cannot be received retroactively.
- 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 Stafford Loan Program, are available to eligible students whether or not they have already received funds from these programs.
- Grants of Title IV Aid (PELL, Supplemental Educational Opportunity Grant, College Work Study, Perkins Loan and Stafford 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 students' (or parents') IRS Form 1040 or 1040A/EZ, if requested;
  - 4) signed affidavits acknowledging Selective Service Registration;
  - 5) proof of permanent residency status, and
  - 6) any other requested documents.
- Students must assume responsibility for reading, understanding and abiding by the terms of all financial aid documents they sign; they should also keep copies of them.
- Students must know each financial aid program's limits on the amount of aid and number of years they can receive such assistance, and make appropriate plans to finance that part of their education which exceeds the limits.
- Students must report any outside financial aid received or any changes in their family situation, so that the Office of Financial Aid can make proper adjustments in awards offered.
- Students must not be in default on a Perkins Loan or a Stafford Loan, nor can they owe a refund on a PELL Grant or a Supplemental Educational Opportunity Grant, if they wish to continue receiving financial aid.
- In order to continue receiving financial aid, a student must maintain full-time, matriculated (degree) status and must complete a minimum number of quarter credit hours with a minimum grade point average to be considered making satisfactory academic progress toward

# REGISTRATION

Registration is the process of obtaining academic advisement and approval of courses from a faculty adviser, recording courses with the Registrar, and paying tuition and fees to the Student Accounts Office/Bursar, according to published deadlines. For complete details about registration dates and procedures, and course schedules, see the Schedule of Classes published prior to each registration period and available from the Registrar.

To receive academic credit, registration is required each semester for every course, including thesis, projects and guided studies. Attendance in class without registration is not permitted.

## ADVISEMENT FOR 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 faculty who will serve as student advisers. Before registration, students must meet with their adviser and receive written 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) and is available from the Registrar prior to each registration.

Approval to register for a course does not necessarily constitute approval to use that course as a substitution for another course in order to satisfy a specific degree requirement. If the course is not usually used for that purpose, such approval should be explicitly requested from the adviser and must be formally granted on the form used for this purpose, the Request for Adjustment of Degree Requirements, and filed with the Office of the Registrar. For example, approval to register for a guided readings course is not necessarily approval to substitute that course for another, similar course prescribed in the curriculum.

Incoming freshmen are required to take Polytechnic placement exams in mathematics and English. These exams are free and are used solely for advisement and

course placement; they do not affect admission to Polytechnic.

## REGISTERING FOR CLASSES

Polytechnic offers three registration periods for each semester and mini-session and two for the Summer terms. In addition, new freshmen entering the Fall semester are offered a special advance registration during the Summer preceding their admission.

**Early registration:** All continuing degree-seeking students (graduate and undergraduate) have the opportunity to early register for the next semester during the latter part of each ongoing semester. Graduate students, particularly those who work, are encouraged to take advantage of early registration by mail. Payment of tuition and fees, or arrangement for payment, is due to the Student Accounts Office no later than the deadline date announced in the Schedule of Classes. Early registration is offered for the Fall and Spring semesters as well as the Winter and Summer mini-sessions.

**Regular Registration:** This usually takes place during the week preceding the start of classes. Information and a registration appointment is mailed to each continuing student who did not early register prior to the regular registration periods for Fall and Spring. New students and special students receive information from the Admissions Office. Payment of tuition and fees is due on the day of registration.

**Late Registration:** Students are expected to complete registration by the end of the fifth day of the semester. The late period, during these first few days of classes, provides a last opportunity to register for the semester. Students who do not complete registration by the end of the late registration period will not be registered for that semester, except by special permission of the Registrar and the course instructor(s). Although permitted, late registration is not desirable as classes may be filled and early meetings of classes missed. A late fee is

assessed all continuing and readmitted students. Payment of tuition and fees is due on the day of late registration.

## PROGRAM ADJUSTMENTS (ADD/DROP)

Additions or deletions to a student program or course schedule may be made during the first five class days of the Fall and Spring semesters or summer sessions. Written approval from the faculty adviser, on the Program Adjustment form, is required for each course added or dropped.

Students may not add or change courses within the freshmen mathematics or physics programs 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.

## 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-ID's must be presented at each registration for validation. ID's must be presented and/or surrendered to any official of the University upon request.

A student ID number is used by the University to identify a student's records (grades, accounts, etc.) from the time of admission through the completion of his/her degree. Student numbers are usually social security numbers, but not always. Students who do not have a U.S. Social Security number at the time of application to the University, as in the case of international students, are assigned a number by the Admissions Office. Assigned numbers may be replaced when a Social Security number is obtained by bringing the original Social Security card to the Office of the Registrar, at which time this number will then become the student's ID number.

## REFUNDS

See the section Tuition and Fees for information on refund policies.

# TUITION AND FEES

Up-to-date and detailed information on tuition and fees as well as announcements of cost changes can be obtained from the Schedule of Classes available before the start of each semester. The Schedule is an official supplement to this Catalog. Tuition and fees are paid by term and not all at once for the entire academic year.

## TUITION COSTS

The following costs are in effect at the time of publication, beginning with the Fall 1993 term.

### Undergraduate students

Full-time (12-20 credits*)	
Each semester	\$7,650.00
Part-time (0.5 - 11.5 credits)	
Each credit/credit hour	\$475.00
Zero credit remedial courses	\$1425.00

### Graduate students

Full-time (12-20 units*)	
Each semester	\$7,650.00
Part-time (0.5 - 11.5 units)	
Each unit	\$525.00

\*All credits/units in excess of 20 must be paid for individually at the per credit/unit rate.

Tuition rates are set by the Board of Trustees. Due primarily to economic conditions and inflationary costs, the University reserves the right to change tuition charges and fees when it is deemed necessary. The University is mindful of the economic hardships of attending a first rate private school such as Polytechnic; accordingly, the University will continue to make every effort to keep cost increases to the lowest possible level consistent with maintaining educational quality.

Tuition covers instruction costs, use of libraries and the facilities of the Office of Student Life.

## OTHER CHARGES AND FEES

Facilities Fee (Required of all students each term of registration)

Full-time	\$100.00
Part-time	\$60.00

Student Activity Fee (required only of undergraduates, payable each term)

Brooklyn	\$40.00
Farmingdale	\$60.00

New Student/Orientation Fee (payable once by new first time, full-time registrants)

\$100.00

Application Fee

Undergraduate	\$40.00
Graduate	\$45.00

Acceptance Deposit\*

\$250.00

Cooperative Education Program Fee

\$65.00

Credit by Examination Fee (undergraduate courses)

per credit \$70.00

Diploma Fee \$50.00

Doctoral Dissertation Microfilm Fee \$75.00

Laboratory/Seminar Fees \*\*

Late Registration Fee \$75.00

Transcript Fee \$5.00

Validation Credit (graduate courses) per unit \$70.00

\*to be applied toward first term's tuition

\*\*Laboratory and course fees are charged for some classes, mostly labs. Lists of these charges by course are given in the Schedule of Classes.

Other fees include the Returned Check Fee, Late Payment Penalty Fee and, for transfer students, possible charges for supplies or kits. Details on these charges can be found in the Schedule of Classes.

All fees are non-refundable.

## HOUSING

Housing charges vary according to arrangements at Brooklyn and Farmingdale. For details, consult the Office of the Dean of Students.

## PAYMENT OF TUITION AND FEES

Each semester, tuition and fee payments are due in full from all students at the time of registration.\* Payment in full refers to various methods, used alone or in combination, including cash, check, money order or credit card (Visa and MasterCard only) financial aid, grants and loans, or tuition arrangements with outside independent agencies. Evidence of financial aid must be presented at registration in order to use the anticipated aid to satisfy tuition costs.

By the end of the semester, tuition must be paid in full, including disbursement of loans, in order to receive permission to register for the next semester. Students participating in the ten month payment plan or the graduate deferment plan must pay in full according to the rules of the plan. The University reserves the right to withhold transcripts, diplomas, and other services, including registration, from students whose financial obligations have not been fully met.

Additional information on the methods of paying tuition is contained in the brochure entitled "A Guide to Paying Tuition at Polytechnic University," which is available from the Office of Student Accounts.

The Office of Student Accounts collects all payments, and checks should be made payable to "Polytechnic University."

\*except for early registration when payment is due by the date specified in the Schedule of Classes, usually about one month prior to the start of classes.

## TUITION AND FEES

### PAYMENT OPTIONS

Tuition payment plans are available from several independent agencies that provide tuition deferment arrangements. Specific information on the plans offered by these agencies can be obtained at the Polytechnic Financial Aid Office or Student Accounts Office.

Also, special education loan programs enable families, or students themselves, to repay over extended periods in monthly installments and are available at many banks for both graduate and undergraduate students.

Another financing option is that 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, so application should be made well in advance of registration.

Graduate students who submit written proof of their eligibility for tuition reimbursement from their employer are eligible for a special deferred payment plan. Under this plan full payment will be due approximately one month after the end of the term. Complete details are in the Schedule and available from the Office of Student Accounts.

The Financial Aid office is available to assist students and their families in pursuing additional payment plan arrangements.

Consult the financial aid section of this catalog for more information on the plans.

### REFUND OF TUITION/REDUCTION OF LIABILITY

This section pertains to all students, regardless of the method of payment or the manner of covering tuition costs. Once registered, students must officially drop or

withdraw from classes in order to be eligible for any applicable tuition refund or to avoid responsibility for payment of charges already assessed. This applies regardless of whether or not classes have been attended. Recipients of financial aid who incur a tuition liability after registration due to a reduction in the aid or to withdrawal from class, will be personally responsible for payment of that liability to the University.

#### Refund Schedule

The refund schedule applies only during the first four weeks of the semester. 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.

Withdrawal forms are available in the Office of the Registrar.

Whenever a student drops or withdraws 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 Office of the Registrar, and
- (3) the withdrawal lowers the student's program to less than 12 credits

Withdrawal during	% Refund
Prior to first day of classes	100%
First Week* of semester	90%
Second Week of semester	75%
Third Week of semester	50%
Fourth Week of semester	25%
After the fourth week of semester	0%

\*In this context, week refers to seven calendar days, excluding holidays. For example, if the term begins on a Thursday and there are no holidays, then the last day of that week would be the following Wednesday.

Students entitled to refunds from program adjustments or withdrawals will have their accounts credited. Students may request that the amount be refunded by check rather than credited to their accounts by writing to the Office of Student Accounts. Refunds are not processed during registration. Normal turnaround time for a refund is two weeks.

Appeals for an exception to the refund schedule must be submitted in writing to the Registrar, along with all documentation which supports the request.

Awareness of University refund policy and withdrawal procedures is expected and lack of this knowledge, by itself, is not sufficient reason for making or granting an appeal.

#### Impact of Refund on Financial Aid

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:

$$\begin{aligned} R &= \text{Amount to be returned to Title IV} \\ &\quad \text{programs} \\ I &= \text{Institutional Refund} \\ T &= \text{Title IV aid for the payment period} \\ &\quad \text{(minus work-study earnings)} \\ A &= \text{Total aid for payment period (minus} \\ &\quad \text{work study earnings)} \\ R &= I * (T/A) \end{aligned}$$

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

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

# PLACEMENT STATISTICS 1992

## SENIOR CLASS

Average starting salaries and statistics listed below are based on surveys returned by our graduates, an average of 66% of the senior class. They describe the activities of our graduates in our largest majors.

### **PLACEMENT RATE— CLASS OF '92: 83%**

#### **AEROSPACE ENGINEERING**

Average starting salary: \$35,057  
Major Employers: General Dynamics, General Electric, Pratt & Whitney, United Technologies, Westinghouse

#### **CHEMICAL ENGINEERING**

Average starting salary: \$38,216  
Major Employers: Exxon Corporation, Sun Chemical, Foster Wheeler, Mobil, Environmental Protection Agency

#### **CIVIL ENGINEERING**

Average starting salary: \$31,588  
Major Employers: Brooklyn Union Gas, Department of Environmental Protection, NYS Dept. of Transportation, Triborough Bridge and Tunnel Authority

#### **COMPUTER SCIENCE**

Average starting salary: \$31,900  
Major Employers: Apple Computers, Morgan Stanley, Swiss Bank, Chase Manhattan Bank, IBM, Goldman Sachs

#### **COMPUTER ENGINEERING**

Average starting salary: \$31,333  
Major Employers: AT&T, Electronic Data Systems, Merrill Lynch, NCR Applied Digital Data Systems

#### **ELECTRICAL ENGINEERING**

Average starting salary: \$31,748  
Major Employers: Bellcore, Brookhaven Labs, Con Edison, Eastman Kodak, IBM, Goldman Sachs, Symbol Technologies, Texas Instruments, Xerox, IRS, Naval Underwater Systems, Lever Bros.

#### **INDUSTRIAL ENGINEERING**

Average starting salary: \$34,800  
Major Employers: Chase Manhattan Bank, Loral Electronic Systems, Metro North

#### **MECHANICAL ENGINEERING**

Average starting salary: \$32,692  
Major Employers: Coca Cola, Con Edison, Ebasco, Ford, Stone and Webster, Lizardos Engineering Associates

# STATISTICS ON ENROLLMENT AND THE STUDENT BODY

## ENROLLMENT 1992-1993

### FALL 1992

	Undergraduate			Graduate			Total
	FT	PT	TOT	FT	PT	TOT	
Brooklyn	1009	158	1167	285	856*	1141	2308
Farmingdale	344	57	401	21	267	288	689
Westchester	N/A	N/A	N/A	9	512	521	521
University totals	1353	215	1568	315	1635	1950	3518

\*includes 63 students studying at an off-campus location

## STUDENT PROFILE

### FALL 1992

	Undergraduate		Graduate	
	Men	Women	Men	Women
Brooklyn	1003	164	994	147
Farmingdale	326	39	246	42
Westchester	N/A	N/A	420	101

## PERSISTENCE AND COMPLETION INFORMATION

*Fall 1991 first-time, full-time undergraduate students continuing at the University in Fall 1992:*

University-wide: 76%      Men: 75%      Woman: 82%

## ENROLLMENT BY RACIAL/ETHNIC STATUS (using standard Federal classifications)

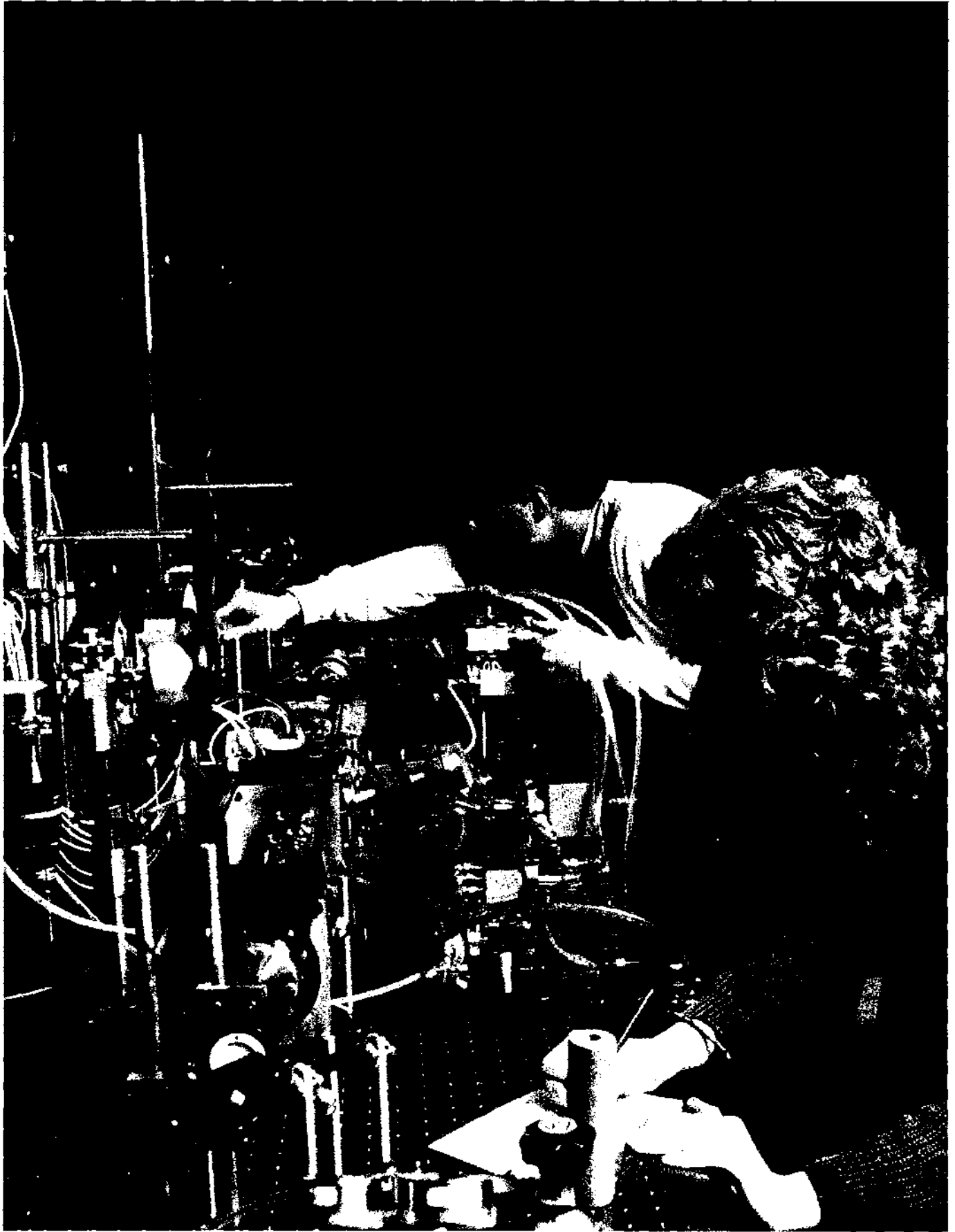
	White	Asian, Pacific Islander	Black, non-Hispanic	Hispanic	American Indian	International (Non-resident alien)
<b>University</b>						
Undergrad	42%	34%	11%	9%	0%	4%
Graduate	53%	17%	6%	4%	0%	20%
<b>Brooklyn</b>						
Undergrad	33%	40%	12%	10%	0%	5%
Graduate	33%	20%	9%	3%	0%	35%
<b>Farmingdale</b>						
Undergrad	67%	19%	5%	6%	0%	3%
Graduate	82%	9%	1%	2%	0%	6%
<b>Westchester</b>						
Graduate	75%	15%	4%	4%	0%	2%

*International students come from more than 50 countries.*

# PART II

## ACADEMIC PROGRAMS, DEGREE REQUIREMENTS AND CURRICULA





# DEGREES OFFERED AT POLYTECHNIC

Polytechnic offers a wide range of degree programs leading to the award of a Bachelor of Science, Master of Science, or Doctor of Philosophy. Polytechnic offers degree programs on three campuses located in Brooklyn, Farmingdale (Long Island), and Hawthorne (Westchester). Not all

degree programs are available on all campuses. The table below lists all available degree programs and the campuses on which they are offered.

Many Ph.D. programs are officially offered only on the Brooklyn Campus. Significant amounts of course work, how-

ever, may be taken at another campus. The location of dissertation research generally depends upon the campus at which the faculty adviser is resident.

For additional details on any of the listed degree programs, consult the appropriate program descriptions of this catalog.

Program Title	HEGIS Code <sup>1</sup>	Brooklyn	Long Island	Westchester
Aerospace Engineering	0902	BS	BS	N/A
Aeronautics and Astronautics	0902	MS	MS, PhD	N/A
Chemical Engineering	0906	BS, MS, PhD	BS <sup>2</sup>	N/A
Chemistry	1905	BS, MS, PhD	N/A	MS
Civil Engineering	0908	BS, MS, PhD	BS, MS	MS
Computer Engineering	0999	BS	BS	N/A
Computer Science	0701	BS, MS, PhD	BS, MS	MS
Electrical Engineering	0909	BS, MS, PhD	BS, MS	MS
Electrophysics	0919	MS	MS, PhD	N/A
Environmental Engineering	0922	BS, MS	BS	N/A
Humanities	4903	BS	N/A	N/A
Industrial Engineering	0913	MS	N/A	MS <sup>3</sup>
Information Systems Eng	0990	N/A	N/A	MS <sup>4</sup>
Materials Science and Engineering	0915	MS, PhD	N/A	MS
Management	0506	MS	MS	MS
Management of Technology	0599	N/A	N/A	MS <sup>3</sup>
Manufacturing Engineering	0913	MS	N/A	MS
Mathematics	701	BS, MS, PhD	N/A	N/A
Mechanical Engineering	0910	BS, MS, PhD	BS	N/A
Operations Management	0506	MS	MS	MS
Organizational Behavior	0514	MS	MS	MS
Physics	1902	BS, MS, PhD	N/A	N/A
Polymer Science and Eng	0906	MS, PhD	N/A	N/A
Social Sciences	2201	BS	N/A	N/A
Systems Engineering	0901	MS	MS	MS
Telecommunications and Computing Management	0599	N/A	N/A	MS <sup>3</sup>
Transportation Management	0510	MS	N/A	N/A
Transportation Planning and Engineering	0908	MS	N/A	N/A

1. Higher Education General Inventory System

2. Some junior and senior laboratory classes must be taken in Brooklyn; transportation arranged.

3. May require some courses to be taken in Brooklyn.

4. Executive format program given on alternate Fridays and Saturdays.

# UNIVERSITY DEGREE REQUIREMENTS

This section details the general university-wide degree requirements which apply to all Polytechnic degrees. They are essentially minimum requirements which apply to all programs and degrees at the University. Academic departments may place additional requirements on individual degrees. Such additional requirements are explained in the programmatic sections of the catalog which follow. In no case, however, may a department specify requirements less stringent than those indicated here.

## BACHELOR OF SCIENCE DEGREES

### BASIC DEGREE REQUIREMENTS

Bachelor of Science degree programs require from 124 to 136 credits, depending upon the major as described in the programmatic sections of the catalog. Students may attend on a part-time or full-time basis, and all degrees may be completed in four years of full-time study. Students must have a cumulative grade-point average 2.0 or better in all courses taken at Polytechnic to earn a bachelor's degree. Some programs may have additional requirements on grades involving specified courses or groups of courses. To earn a Polytechnic Bachelor of Science degree, the student must take a minimum of 34 credits of junior- and senior-level courses at Polytechnic in order to fulfill residency requirements.

Virtually all undergraduate courses are given during the day. A selection of evening undergraduate courses is available, but it is no longer possible to complete any undergraduate degree by taking courses entirely in the evening.

### PLACEMENT EXAMINATIONS

Polytechnic gives all incoming freshmen placement examinations in writing and mathematics, as well as an entrance questionnaire concerning computer background. Each of these examinations, and the resulting placements are discussed in the paragraphs below.

#### Writing Placement Examination

Both employers and accrediting organizations are placing increasing emphasis on the need for well-developed written and verbal communications skills. No engineer or scientist can be an effective professional without the ability to communicate not only with other professionals in his/her own field, but with professionals in other technical and non-technical fields, with private and public decision-makers, and with the general public.

Polytechnic's programs involve frequent writing and speaking assignments across all areas of the curriculum, and it is essential that all students have the appropriate background skills before getting too far into their professional studies.

All incoming freshmen and most transfer students will be required to take a writing placement examination. Students fall into two general groups: those with an English-speaking background, and those with an English as a Second Language (ESL) background.

Based upon the results of the placement examination, students with an English-speaking background will be placed in either:

HU 101 Writing and the Humanities I or HU 009 Introductory Composition	3 credits    0 credits
--	------------------------------------

Students with an ESL background will be placed in either:

HU 103 Writing and the Humanities I (ESL)	3 credits
or HU 008 Reading and Writing in English as a Second Language	0 credits

Students completing HU 101 or HU 103 proceed to take HU 200, Writing and the Humanities II. Students completing HU 009 proceed to take HU 101, while those completing HU 008 go on to take HU 103. Students placed in HU 008 or HU 009 are encouraged to take these courses over the summer preceding their freshman year. They are made available at significantly reduced cost for students who do so. Students unable to take a course over the summer may take HU 008 or HU 009 during their first regular semester. Typical schedules can be rearranged to accommodate this.

#### Mathematics Placement Examination

The mathematics placement examination tests students' skills in advanced algebra and trigonometry. This has been especially important for students from New York State high schools, where the sequential mathematics curriculum has left many with insufficient preparation in these important areas through no fault of their own.

Those who are found to need additional instruction in this area are placed in MA 105 - Introduction to Calculus (2 credits), while those who do not need additional instruction are placed in MA 106 - Calculus I (3 credits). The credits for MA 105 do not count towards B.S. degree requirements except for Humanities/Social Sciences majors, but do affect the grade point average (G.P.A.).

It has become apparent in recent years that the majority of high school students need additional support in advanced algebra and trigonometry. This is not a reflection of the quality of the student (virtually all Polytechnic students are in the top 20% of their graduating classes), but on the high-school curriculum to which they have been exposed. We have found that it is better to

invest the time in another mathematics course than to jump right into college calculus and experience difficulties. Again, students placed in MA 105 are urged to take this course during the summer preceding their first semester. The course is made available to such students at significantly reduced cost. Students unable to take MA 105 over the summer may do so during their first regular semester. Typical schedules can be rearranged to accommodate this.

**Computer Placements**

All freshman take CS 200, Programming Methodology, during their first semester of study. Sections of this course are, however, segregated for students who have had significant hands-on experience with computers previously and those who have had very little experience with computers previously. The placement determination is made using a questionnaire filled out by each student. Those in the "inexperienced" section will receive additional instruction on basic computer usage.

All of Polytechnic's placement examinations are intended to insure that each student receives the exact instruction in basic areas needed to insure successful completion of the degree program they have chosen. Placement examination results are superceded by the results of Advanced Placement examinations and/or acceptable transfer credits from another institution of higher education.

**CORE CURRICULUM FOR ENGINEERING MAJORS**

All engineering majors must follow the core curriculum outlined in this section. Non-engineering majors will take appropriate parts of this core, as described in the programmatic sections of this catalog. Students entering the University as undeclared majors are also required to follow this core curriculum, and may select any Polytechnic major without loss of credits up to the end of one year of study.

The core curriculum is intended to insure that every engineering student is exposed to an appropriate mix of general preparatory courses in the liberal arts, mathematics, and the basic sciences. It is also intended to insure a breadth of knowledge of fundamental engineering principles, and an appreciation and understanding of all engineering disciplines.

There are four components to the core curriculum, including the (1) liberal arts core, (2) mathematics core, (3) basic science core, and (4) engineering and computer science core. Each of these components is described in the paragraphs which follow.

**Liberal Arts Core**

Every engineering student must take a minimum of 27 credits of course work in the humanities and social sciences. These courses have two objectives—the development of communications skills and an exposure to an appropriate balance of study in liberal arts content areas. Both are critically important, and contribute to the general literacy of engineering undergraduates in dealing with the world and societal issues which set the context for the practice of their professions.

All students must take the following *required* courses (12 credits):

HU 101/103	Writing and the Humanities I	3 credits
HU 200	Writing and the Humanities II	3 credits
HU 110	Professional Report Writing	3 credits
SS 104	Contemporary World History	3 credits

Students placed in HU 008 or HU 009 must successfully complete these courses before beginning HU 101 or 103. HU 103, if required, must be completed before registering for SS 104, and HU 200 is a desirable co-requisite.

To complete the minimum liberal arts requirements, each engineering student must elect two additional courses in the humanities, and three additional courses in the social sciences (15 credits). In the humanities, electives are available in Literature, Philosophy, Fine Arts, or Modern Language. In the social sciences, electives are available in History, History of Science, Economics, Psychology, and Sociology/Anthropology. In the case of the three required Social Science electives, at least one course must be other than SS 250, SS 189, or the introductory course in Sociology/Anthropology (SS 184 effective Spring 1994). Courses comprising these focus areas are described in the "Humanities" and "Social Sciences" portion of the catalog. Each semester, a listing of available courses in each area is published to assist students and faculty

advisers in selecting appropriate courses to complete an acceptable sequence.

Students may elect to take a Modern Language sequence. A minimum of three courses must be taken in the same language. Students electing this option must take only two Social Sciences (of which at least one must be other than SS 250, SS 189, or SS 184).

**Mathematics Core**

Every engineering student must take a minimum of 17 credits of study in mathematics. Four courses are required of all students:

MA 106	Calculus I	4 credits
MA 107	Calculus II	4 credits
MA 108	Differential Equations and Numerical Methods	3 credits
MA 109	Multidimensional Calculus	3 credits

Each discipline specifies one additional 3-credit mathematics course in one of the following general areas: probability, probability and statistics, linear algebra, numerical analysis, or advanced calculus. Consult the programmatic sections of the catalog for information on specific requirements for each discipline.

A unique feature of Polytechnic's mathematics curriculum is the use of the Harvard Method for teaching calculus. This innovative technique focuses on the use and application of mathematics to solve physical problems. It also presents each mathematics concept in three ways: algebraically, graphically, and numerically. The method is particularly appropriate for engineering majors who will use mathematics as a critical tool to model physical phenomena and to solve physical problems.

Students placed in MA 105 must successfully complete this course before beginning the required sequence described above.

**Basic Science Core**

The basic science core consists of 16 credits of study in the critical areas of Chemistry and Physics. The following courses are required of all engineering majors:

CM 101	General Chemistry I	2.5 credits
CM 111	General Chemistry Laboratory I	0.5 credits

## UNIVERSITY DEGREE REQUIREMENTS

CM 102	General Chemistry II	2.5 credits
CM 112	General Chemistry Laboratory II	0.5 credits
PH 107	Mechanics	3.0 credits
PH 108	Electricity, Magnetism, and Fluids	3.0 credits
PH 118	Physics Laboratory for PH 108	0.5 credits
PH 109	Waves, Optics, and Thermodynamics	3.0 credits
PH 119	Physics Laboratory for PH 109	0.5 credits

Although they are given separate course numbers, courses and their associated laboratories should be taken concurrently.

### Engineering and Computer Science Core

The centerpiece of the core curriculum for engineering majors is the engineering and computer science core of 22 credits. This portion of the curriculum is intended to insure that all engineering majors have a common base of knowledge of key engineering principles, and a thorough appreciation of the range of applications of these principles across the engineering disciplines. A major element of this part of the core is the freshman engineering sequence, which provides an early introduction and immersion in engineering both as an intellectual discipline and a professional pursuit.

The Accreditation Commission for Engineering and Technology (ABET) defines six fundamental areas of engineering: mechanics, electric and electronic circuits, materials science, thermodynamics, transport phenomena, and computer science (not including programming skills). The engineering and computer science core is constructed to guarantee that every engineering major is exposed to each of these fundamental areas. All engineering students are required to take the following courses:

EG 101	Introduction to Engineering	3 credits
EG 102	Introduction to Engineering Design	3 credits
CS 200	Programming Methodology	3 credits
XX YYY	Senior Design Project	4 credits

Transfer students replace EG 101 and EG 102 by advanced technical courses, if

they enroll in the University as sophomores or later.

EG 101/102 constitutes the freshman engineering program, and focuses on hands-on experiential learning, and on the process of engineering design as the single most unique professional function of the engineer. Each major defines its own senior design projects, but every engineering student will complete one.

To complete the engineering core, each engineering disciplinary curriculum must specify one course focusing on each of three of the fundamental areas of engineering discussed previously. At least one of these courses will be taught in an engineering department (including computer science) other than the student's major.

### Writing and Speaking Across the Curriculum

Polytechnic has adopted a "writing and speaking across the curriculum" program to insure the development of adequate communications skills on the part of all graduates. The program simply means that significant writing and speaking assignments will be included in designated courses throughout the student's undergraduate program, and that the grades for these courses will be influenced by the quality of presentation in addition to mastery of content. It is expected that every full-time Polytechnic undergraduate will have at least one such course in every semester of registration.

To support this program, a writing learning center has been established at the Brooklyn Campus, staffed by instructors and qualified tutors. Appointments can be made to assist in improving writing and/or speaking skills. Similar services are available on the Farmingdale Campus through the Department of Humanities and Communications.

Core courses such as HU 101/103, HU 200, SS 104, EG 101, EG 102, all HU/SS electives, and all senior design projects are "writing and speaking intensive" courses. Each disciplinary curriculum identifies other courses which will fit into this category as well.

### FRESHMAN SEMINAR

All incoming freshmen, including transfer students with less than 6 credits, are required to take "Freshman Seminar," SL 101. This seminar includes weekly discussions and presentations on time man-

agement, study and test-taking skills, available support services at Polytechnic, and many other subjects of importance to beginning students. A short paper on the selection of a major is required of all students in this non-credit hearing course.

At the end of this course, students will be given the opportunity to confirm or change their major. Undeclared majors may choose to select a major, or may remain undeclared until the end of the freshman year, at which time a major must be declared. In general, the major can be changed at the end of the first semester or at the end of the freshman year without loss of credits.

### GRADUATION CHECKLIST

Undergraduates who are nearing completion of their degree requirements 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 major academic department, the check list is mailed to students by the Registrar. Check lists are prepared for full-time students after completion of 85 credits; for part-time students after 105 credits. A revised check list will be issued to any student who does not complete his or her degree program within a reasonable period after issuance of the initial check list.

### COURSE SUBSTITUTIONS AND OTHER MODIFICATIONS TO CURRICULA

Curricula sometimes change in order to keep students abreast of the latest knowledge and methods within the subject area, especially in the science, engineering and technology areas taught at Polytechnic. Students will be informed of these changes by their major department. Because of changes in curricula and course content, and to address special situations, it is occasionally necessary to substitute a course for one specified in the curriculum to meet degree requirements. Such substitutions are documented on an "Adjustment of Degree Requirements" form, commonly known as a "blue sheet" because of its color. The form is available from the Registrar's Office. Each substitution must be documented on a form, and each must be approved by the student's major faculty adviser and by the

Vice-President for Academic Affairs. If a graduation check list has already been issued at the time of the substitution, the change should be formally entered on the check list and approved by the major adviser and Vice-President for Academic Affairs.

Students who have interrupted their studies for a length of time are likely to have degree requirements evaluated according to the curriculum in effect at the time of readmission, not according to the curriculum in effect at the time the student first matriculated. This is to ensure that the coursework used to fulfill degree requirements is current and meets the current standards in the field. At the time of readmission, the student should discuss with the adviser the specific courses remaining to be taken for graduation as well as the applicability toward the degree of courses already taken.

## SENIOR HONOR STUDENTS

Each spring, departments select students with high grade-point averages who will complete their degree requirements in the following academic year. Such students are listed as Honor Students in that year's commencement program, and are given special permission to make substitutions in their selection of senior courses. Most often, this takes the form of substituting more advanced graduate courses in place of usual requirements in the same area of study. To be eligible for this designation, transfer students must complete 1/2 of the credits needed to satisfy degree requirements at Polytechnic.

## DEGREES WITH HONORS

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

B.S. Cum Laude	3.40 - 3.59
B.S. Magna Cum Laude	3.60 - 3.69
B.S. Summa Cum Laude	≥ 3.70

To be eligible for graduation with honors, transfer students must have completed a minimum of 60 credits towards their degree requirements at the Polytechnic.

## DUAL MAJORS

A *dual major* is a single B.S. degree with two major disciplines indicated on the degree. A student may receive a degree indicating dual majors if he or she:

- is assigned a home department which will be responsible for the student's primary (first) major.
- applies for and is admitted to the second department in the same manner as a student who wishes to change majors, and
- has, prior to graduation, approval from each department of the courses for its major.

Interested students should consult departmental advisers, as not all disciplines are available as dual majors.

## DUAL UNDERGRADUATE DEGREES

It is also possible for students to earn two separate B.S. degrees in two disciplines. Special requirements for each degree are determined by the departmental undergraduate adviser or department head for each department, in accordance with the following rules:

- The set of courses includes all of the required courses for each degree. Some elective credits for one curriculum may be fulfilled with required credits from the other, given that sufficient senior/graduate level electives are completed to provide depth in each discipline.
- The total credits required for both degrees must exceed those required for one of the degrees by at least one full year of credit. Courses satisfying requirements in both degrees may be counted only once for this purpose. Total credits required for the two degrees is, therefore, computed using the following formula:

$$\text{Total Credits} = \text{Credits (Degree 1)} + \text{Credits (Degree 2)} / 4$$

This is a minimum, and some combinations of degrees may require additional credits. Where the two majors are closely related, such as electrical engineering and computer science, physics and electrical engineering, mechanical engineering and aerospace engineering, etc., five years of study will generally suffice to earn both degrees. Where the two degrees are less closely related, such as civil engineering and chemistry, electrical engineering and humanities, mechanical engineering and physics, etc., additional credits and more than five years would be required.

- Students working towards two degrees must: (1) register in a "home" department which will be responsible for the student's primary (first) degree, and notify the department of the intent to pursue a second degree, (2) apply for and receive admission to the second department in the same manner as a student wishing to change departments, (3) obtain approval from both departmental faculty advisers when registering or withdrawing from a course, (4) maintain good academic standing in the University, and in each academic department, and (5) complete all courses specified in the graduation check list provided by each department with satisfactory grades.
- Both degrees may be simultaneously earned, or one may be earned subsequent to the other. Graduation honors for each degree are separately determined.

To graduate in the minimum amount of time with two degrees, students should choose this option as early as possible. The courses of the two degree programs can then be interwoven to provide good academic continuity and to satisfy all prerequisites in an orderly fashion. Please note that many students, rather than earn two undergraduate degrees, prefer to earn a single baccalaureate degree followed by a master's degree in a different, but related, discipline.

Students interested in the two-degree option should check with their undergraduate advisers, as not all combinations of disciplines can be conveniently packaged in this manner.

## MASTER OF SCIENCE DEGREES

Admission to Master of Science degree programs requires a bachelor's degree from an institution acceptable to the Polytechnic in an appropriate preparatory discipline. Candidates for Master of Science degrees must complete not less than 36 units of advanced study and/or research beyond the bachelor's degree in the program selected. Specific course requirements for each Master of Science program are detailed in the programmatic descriptions of this catalog.

Effective Fall 1983, to obtain any graduate degree or certificate, students must maintain 3.0 grade-point average or better in all graduate courses taken at the Polytechnic, including those not used to fulfill specific program requirements; and a B or better average in all guided studies efforts (including readings, project, thesis, and dissertation).

Students may offer no more than 12 units of project, special student units and/or thesis towards fulfillment of Master of Science degree requirements. Registration in project and/or thesis must be continuously maintained until the work is completed and a grade recorded.

A maximum of nine (9) units may be accepted as transfer and/or validation credits, the latter not to exceed six (6) units. All requirements for the Master of Science degree must be completed within a period of no more than five years after beginning graduate studies at Polytechnic. Any extension of this period requires the approval of the V.P. for Research and Advanced Programs. A minimum of 27 units of work must be taken at the Polytechnic.

Individual programs may specify required courses, minimum grade-point averages in specific courses or course groups, and/or require a comprehensive examination, presentation of a seminar, or completion of a project or thesis.

## DOCTOR OF PHILOSOPHY DEGREES

Requirements for the Ph.D. 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 at an advanced level.

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

All candidates for the doctorate must complete a minimum of 90 units of graduate work beyond the bachelor's degree, including a minimum of 24 units of dissertation research.

Students may not register for dissertation research until they have passed the doctoral qualifying examination given by their major department. These examinations are generally scheduled once or twice each year, and students should consult the academic department for specific information. Once the student has started the dissertation, registration for dissertation must be continuous until the dissertation has been completed and accepted, unless a leave of absence is formally granted.

Most departments have specific course requirements which must be fulfilled. A minimum of 30 units, including dissertation, must be taken at Polytechnic. Each student must maintain a 3.0 cumulative grade-point average for all graduate courses taken at Polytechnic, and a B or better average for the dissertation. Foreign language requirements, if any, are determined by the individual departments.

Full-time doctoral students are required to complete all work for the doctorate within six (6) years of initiation of graduate work at Polytechnic. Part-time students must complete within twelve (12) years. Any extension of these periods requires the approval of the V.P. for Research and Advanced Programs.

## GRADUATE CERTIFICATE PROGRAMS

Polytechnic offers a number of graduate certificate programs in a number of specialized subject areas for students who may not wish to enroll in a full degree program. These programs are described in the appropriate programmatic section of the catalog.

To earn a certificate, a minimum of 12 units must be taken at Polytechnic. A cumulative grade-point average of 3.0 in all graduate courses taken at Polytechnic is required for receipt of a certificate. No courses applied to one certificate program can be applied to another. Requirements for certificates must be completed within three years.

Applicants must be formally admitted to a certificate program. A student in such a program who subsequently decides to pursue a graduate degree must file a separate application for admission to the regular graduate program. Formal application to transfer appropriate courses taken for the certificate program to a degree program must also be made.

The following graduate certificate programs are available, and are described in the program sections of this catalog:

Program	HEGIS Code*
Management and Business Adm.	0506
Applied Statistics	1702
Computer Applications	1701
Computer Mathematics	1703
Construction Management	0599
Econometrics and Forecasting	2204
Economics	2204
Economics Systems	2204
Engineering Statistics	1702
Finance	0504
Human Resources	0515
Industrial Engineering	0913
Mathematical Programming	0704
Mathematical Statistics	1702
Operations Management	0506
Operations Research	0507
Organizational Behavior	0515
Polymeric Materials	0906
Production and Inventory Control	0913
Public Policy	2102
Public Transportation	0908
Quality Control and Reliability	0913
Technology Management	0599
Traffic Engineering	0908
Transportation Facility Design Operations	0908
Transportation Management and Economics	0908
Transportation Planning	0908

\*Higher Education General Inventory System - a taxonomy of programs and subject areas

## APPLICATION FOR DEGREE

Formal application for the award of any Polytechnic degree or certificate 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. and M.S. degrees are available in the Office of the Registrar. Applications for the Ph.D. degree are available in the Office of Research and Graduate Studies. Degrees are certified, and diplomas issued, twice a year, at the end of the Fall and Spring semesters. Degrees are conferred at the annual Spring commencement held in late May or early June. All work for the degree must be completed and submitted prior to the date of graduation.

Filing fees for diplomas are payable at the time of filing in the Office of the Bursar. If the award of a 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.

## THESES AND DISSERTATIONS

### UNDERGRADUATE THESES

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

All undergraduate students who plan to undertake a thesis 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. Thereafter, the student must register for thesis every fall and spring until the thesis is completed and accepted, and the final grade is entered into the student's permanent record.

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

Undergraduate theses are generally optional, except in the B.S. (Materials Science and Engineering) program, in which undergraduate students are required to complete a thesis. All theses and results obtained become the property of the Polytechnic University.

### GRADUATE RESEARCH (PROJECTS, THESES, DISSERTATIONS)

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 the advancement of 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 commensurate acquaintance with current practices, the literature, and the work of leaders in the field of study.

Master of Science students may elect to complete an M.S. Project or M.S. Thesis, and may be required to do so in certain programs. Consult the programmatic descriptions of this catalog for details. The thesis is generally a more extended piece of work, usually entailing 9 to 12 units, while the project usually entails 3 to 6 units of effort. At this level, research shall exhibit a thorough understanding of advanced scientific thought or ability to apply advanced principles constructively to engineering planning and design.

All Doctor of Philosophy students must complete a Ph.D. Dissertation. Research at this level must demonstrate critical and constructive thought, as well as the ability to use the techniques necessary in the exploration and development of new areas of knowledge in science or engineering. A successful dissertation must demonstrably advance the state-of-the-art in the subject area of research. Unit requirements for dissertation vary by department, but consist of a minimum of 24 to 30 units of registration, depending upon the program.

All research should be characterized by accuracy of observation and measurement, 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, thesis, or dissertation adviser and/or guidance committee has been appointed, the candidate should register for a number of units which realistically reflects the amount of time and effort the candidate expects to devote to this research. Registration must be continuous each fall and spring until an adequate research effort has been completed and the required oral examination has been passed. Registration may not be interrupted until a grade is entered on the permanent record except with the permission of the V.P. for Research and Advanced Programs. If, at the end of any semester, the work covered by any unit of registration is deemed unsatisfactory by the adviser, re-registration for the same unit may be required, obligating the student for full tuition and laboratory fees involved. Registration for the last unit is required until a final grade is submitted to the Office of the Registrar.

For the Ph.D., if the minimum number of dissertation units have already been taken and the dissertation is finished except for the final defense, then the student will be allowed to register for the dissertation for 1/2 unit in order to keep the tuition charges to a minimum. Registrations for 1/2 unit may only be done once.

### 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 towards 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 document resulting from research is prescribed in a brochure entitled "Regulations on Format,

## UNIVERSITY DEGREE REQUIREMENTS

Duplication, and Publication of Project Reports, Thesis, and Dissertations," which is available from the Office of Research and Graduate Studies and in the various departmental offices. Some of the regulations are summarized below.

Master's or Engineer's 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 appropriate signatures 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 the Polytechnic library.

### ***PUBLICATION***

Doctoral dissertations will be microfilmed at University Microfilms, Ann Arbor, Michigan, and abstracts of them will be published in the journal "Dissertation Abstracts." The cost of this service will be charged to the student. Copies of these microfilms may then be purchased from University Microfilms by any interested person.

The faculty regards publication of the major content of a doctoral dissertation in a recognized scientific journal as a necessary final step if the work performed is to achieve maximum usefulness. The publication must indicate, by footnote or otherwise, its basis as a Polytechnic University dissertation.

# A BRIEF GUIDE TO COURSE DESCRIPTIONS

Each program section which follows contains detailed descriptions of each course offered within the program. A sample course description follows:

## **MA 123 Experimental Design**

2½; 1½; 0; 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-Requisite: MA 153*

**Also listed under IE 123**

The first line gives the official *course number* for which you must register, the official *course title*, and the breakdown of credits (undergraduate) or units (graduate) for the course. In the sample description, the courses meets for 2½ lecture periods, 1½ laboratory periods, and no recitation periods per week. If successfully completed, 4 credits are earned.

The paragraph description briefly indicates the contents and coverage of the course. A detailed course syllabus may be available on request from the office of the offering department.

“Prerequisites” are courses (or their equivalent) which *must* have been completed before registering for the described course. “Corequisites” must be completed before registering for the subject course, or may be taken concurrently.

The notation “Also listed...” indicates that the course is also given under the number shown. This means that two or more departments or programs are sponsoring the described course, and that you may register under either number, usually the one representing your major program. The classes are jointly given and held.

# AEROSPACE ENGINEERING

Among the programs offered by the Department of Aerospace Engineering is the undergraduate program leading to a bachelor of science degree in aerospace engineering. Others lead to graduate degrees in aeronautics and astronautics. The undergraduate program is offered at both the Brooklyn and Long Island campuses. Graduate degrees are offered at the master of science and doctor of philosophy levels only at the Long Island campus.

## THE AEROSPACE ENGINEERING PROFESSION

Aerospace engineering is the art and science associated with the design and performance of aircraft, missiles, and spacecraft. The scientific aspects of space vehicle design are rooted in the broad areas of the flow of liquids and gases, strength and stability of extremely lightweight structures, propulsion, guidance and control, materials, environmental conditions, thermodynamics, and heat transfer.

From the standpoint of complexity, scope of engineering and scientific problems, and audacity of the mission, vehicles currently being designed or projected for the future stagger the imagination. Until recently, long range missiles, moon vehicles, deep space probes and space habitats, had been contained within the realm of science fiction. To meet the challenges of the design of these vehicles, aerospace engineering training is based on scientific principles that provide the engineer with the greatest possible potential and flexibility. Conflicting requirements imposed by considerations of safety, reliability, cost, maintenance, production, and handling often demand compromises based upon the engineer's skill and experience in order to attain an

optimum design. It is the responsibility of the aerospace engineer to resolve such issues.

## UNDERGRADUATE PROGRAM

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, oceanography, 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, space dynamics, flight mechanics, propulsion, and airplane and spacecraft design.

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

## TRANSFER STUDENTS (Undergraduates)

Qualified graduates of two-year pre-engineering programs, such as those at liberal arts and community colleges, may fulfill the requirements for the B.S. degree in aerospace engineering in two additional years. Since pre-engineering programs vary, a prescribed program is not possible; consequently, students should consult with an undergraduate adviser.

Graduates of technology programs may be able to fulfill the requirements for the B.S. degree in aerospace engineering in two to three and a half years depending on the scope and level of their previous education. Consult with an undergraduate adviser for details.

## GRADUATE PROGRAM

Programs of study are offered leading to the degrees of master of science and doctor of philosophy in aeronautics and astronautics. Bachelor's degrees in aerospace or mechanical engineering are generally required. Applicants with degrees in other fields may be admitted with deficiencies.

To obtain any graduate degree or certificate, a student must have a 3.0 grade point average or better in all graduate courses taken (whether or not some of these courses are being used to satisfy specific degree requirements) and a B or better average in all guided studies (readings, project, thesis, dissertation). Additionally, students must establish an overall B average in those departmental courses submitted in partial fulfillment of degree requirements. All courses submitted for degrees must have been completed within the time periods given in the University catalog.

**REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE**

AE 731	<i>Analytical Methods in Thermal &amp; Fluid Mechanics</i>	3
AE 732	<i>Computational Methods in Thermal &amp; Fluid Mechanics</i>	3
AE 740	<i>Principles of Fluid Dynamics</i>	3
AE 741	<i>Compressible Flow</i>	3
AE 742	<i>Viscous Flow</i>	3
AE 810	<i>Theory of Propulsion</i>	3
AE 971-72	<i>Seminar in Aerospace Engineering</i>	0
Electives	<i>(including project or thesis)</i>	18
		<u>36</u>

In the above master's degree program 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 adviser and should be consistent with a definable objective associated with the master's program. The Department of Aerospace Engineering offers its graduate courses *only* at the Long Island Campus, which is the main location of departmental research laboratories and staff. Students may take out-of-department elective courses at either the Brooklyn or the Long Island campus (subject to approval by the graduate adviser).

The department limits to nine the total of transfer, reading (guided studies), and validation credits which can be applied toward master's degrees. The certification of validation credits is administered by the departmental graduate advisers.

**REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE**

Master's degrees in aerospace or mechanical engineering 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.

Students interested in the Ph.D. program are required to consult as soon as

possible with a departmental graduate adviser regarding eligibility for the qualifying examinations and other regulations.

All candidates for the Ph.D. must complete a minimum of 30 units of approved courses beyond the master's degree. 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 AE 971-72 (Seminar in 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 completed within time periods consistent with general University regulations.

**TYPICAL COURSE OF STUDY FOR THE BACHELOR OF SCIENCE DEGREE IN AEROSPACE ENGINEERING**

**FRESHMAN YEAR**

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
<b>Fall Semester</b>				
CM 101	<i>General Chemistry I</i>	2½	0	2½
CM 111	<i>General Chemistry Lab I</i>	0	1½	½
MA 106	<i>Calculus I</i>	5	0	4
CS 200	<i>Intro. to Programming Methodology</i>	4	0	3
HU 101	<i>Humanities I</i>	3	0	3
SL 101	<i>Student Survival</i>	1	1	0 <sup>a</sup>
EG 101	<i>Intro. to Eng.</i>	2	3	<u>3</u>
				16
<b>Spring Semester</b>				
CM 102	<i>General Chemistry, II</i>	2½	0	2½
CM 112	<i>General Chemistry Lab. II</i>	0	1½	½
MA 107	<i>Calculus II</i>	5	0	4
PH 107	<i>Mechanics</i>	4	0	3
HU 200	<i>Humanities II</i>	3	0	3
EG 102	<i>Intro. to Eng. Des.</i>	2	3	<u>3</u>
				16

<sup>a</sup> HU/SS electives must meet the concentration requirements described in the section of this catalog entitled "Core Curriculum Requirements", subsection "Humanities and Social Sciences Requirements for Engineering and Computer Science Majors."

<sup>b</sup> Technical Electives must be of senior-year quality and professionally relevant. Adviser approval required for all Technical Electives.

**SOPHOMORE YEAR**

**Fall Semester**

MA 108	<i>Diff. Eqs. &amp; Num. Methods</i>	3	0	3
PH 108	<i>Elect. Mag. &amp; Fluids</i>	4	0	3
PH 118	<i>Physics Lab. for PH 108</i>	0	1½	½
ME 111	<i>Mechanics I</i>	3	0	3
HC 110	<i>Report Writing</i>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>	3	0	3
SS 104	<i>Cont. World Hist.</i>			
AE 341	<i>Intro. to Aero Des.</i>	1	3	<u>2</u>
				17½

**Spring Semester**

MA 109	<i>Multidim. Calc.</i>	4	0	3
PH 109	<i>Waves, Optics &amp; Thermo.</i>	4	0	3
PH 119	<i>Physics Lab. for PH 109</i>	0	1½	½
ME 112	<i>Mechanics II</i>	3	0	3
ME 121	<i>Mechanics of Materials</i>	3	0	3
SS 104	<i>Cont. Wrld. Hist. OR</i>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>			
PH 234	<i>Modern Physics</i>	2	0	<u>2</u>
				17½

**JUNIOR YEAR**

**Fall Semester**

MA 222	<i>Intro. Prob. &amp; Statistics</i>	3	0	3
ME 201	<i>Thermodynamics I</i>	3	0	3
AE 231	<i>Fluids I</i>	3	0	3
AE 271	<i>Fund. Stress Analysis I</i>	3	0	3
AE 311	<i>Mechanics of Flight I</i>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>	3	0	<u>3</u>
				18

**Spring Semester**

AE 232	<i>Fluids II</i>	3	0	3
AE 251	<i>Space Dynamics</i>	3	0	3
AE 272	<i>Fund. Stress Analysis II</i>	3	0	3
AE 342	<i>Aircraft Design I</i>	2	3	3
EE 370	<i>Princ. of Elect. Eng.</i>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>	3	0	<u>3</u>
				18

**SENIOR YEAR**

**Fall Semester**

AE 233	<i>Fluids III</i>	3	0	3
AE 281	<i>Advanced Stress Analysis I</i>	2	1	3
AE 343	<i>Aircraft Design II</i>	2	3	3
AE 349	<i>Fluids Laboratory I</i>	1	3	2
Technical Elective <sup>b</sup>	<b>OR</b>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>	3	0	<u>3</u>
				17

**Spring Semester**

AE 241	<i>Propulsion</i>	3	0	3
AE 312	<i>Mechanics of Flight II</i>	3	0	3
AE 344	<i>Spacecraft Design</i>	2	3	3
AE 350	<i>Fluids Laboratory</i>	0	3	1
Technical Elective <sup>b</sup>	<b>OR</b>	3	0	3
HU/SS Elective <sup>a</sup>	<b>OR</b>	3	0	<u>3</u>
				16

Total credits required for graduation: 136

**UNDERGRADUATE COURSES**

**AE 231 Fluids I 3:0:0:3**

Fluids, kinematics, hydrostatics, thermodynamics. Derivations of continuity, momentum and energy equations. Flux concepts and relation to divergence theorem. Control volume equations and applications. Bernoulli equation. Discussion of vorticity and stream function. Potential flows over simple geometric configurations. *Prerequisites: MA 109, ME 112.*

**AE 232 Fluids II 3:0:0:3**

One-dimensional unsteady flow, shock tube, Prandtl-Meyer flow, oblique and normal shocks. Method of characteristics. Laval nozzle flow. Fanno and Rayleigh flows. *Prerequisite: AE 231, ME 201.*

**AE 233 Fluids III 3:0:0:3**

Introduction to viscous flow theory. Viscous effects. Stress-strain relations. Reynolds transport theorem. Derivation of Navier-Stokes equations. Rayleigh problem and diffusion time. Similarity theory. Prandtl boundary layer equations, flow over a flat plate. Approximate methods, numerical methods. Separated flows. *Prerequisite: AE 231.*

**AE 234 Fluids IV 3:0:0:3**

One dimensional unsteady flow, characteristics, conical flow, linearized subsonic and supersonic flow over wings and bodies. *Prerequisite: AE 232.*

**AE 241 Propulsion 3:0:0:3**

Operation, performance, and design methods for flight vehicle propulsion systems. Airbreathing engines: turbojet, turboprop, turbofan and ramjet. Elements of rocket propulsion systems. *Prerequisite: AE 232.*

**AE 242 Rocket Propulsion 3:0:0:3**

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. Heat transfer fundamentals. *Prerequisite: AE 232.*

**AE 251 Space Dynamics 3:0:0:3**

Motion of a particle, systems of particles, rigid bodies. Momentum and energy principles and applications. Impulsive forces and moments. Projectiles with air resistance, trajectories and orbits, gyroscopic theory. *Prerequisites: ME 112, MA 108.*

**AE 271 Fundamentals of Stress Analysis I 3:0:0:3**

Stress, equilibrium equations, strains, compatibility conditions, stress strain relations, superposition, strain energy. Bending of beams: unsymmetric bending of arbitrary section beams, bending stresses, deflections, shear stresses on thin-walled section beams, shear center. *Prerequisite: MA 108, ME 121.*

**AE 272 Fundamentals of Stress Analysis II 3:0:0:3**

Torsion of thin-walled open and closed section beams. Membrane and hydrodynamic analogies. Bredt's formula, multicelled cross sections. Strain energy, Castigliano's theorems. Statically indeterminate beams, frames, rings. *Prerequisite: AE 271.*

**AE 281 Advanced Stress Analysis I 2:3:0:3**

Elastic and inelastic buckling of columns, frames, plates, shells, effective width, sheet-stringer combinations, torsional instability, energy methods for approximate solutions. Laboratory: experimental stress analysis, strain gages, shear center, tension tests, bending of beams. *Prerequisite: AE 272.*

**AE 282 Advanced Stress Analysis II 3:0:0:3**

The finite element method as applied to beams, trusses and frames in conjunction with the principle of virtual work. *Prerequisite: AE 272.*

**AE 311 Mechanics of Flight I 3:0:0:3**

Principles of powered flight. Development of equations of motion. Level flight performance of turbojet and propeller driven aircraft, climbing flight, ceiling, take-off and landing. Steady turning flight. *Prerequisites: ME 112.*

**AE 312 Mechanics of Flight II 3:0:0:3**

Static and dynamic stability and control of aircraft and missiles. Development of rigid body equations of motion, linearization of equations of motion of airplanes. *Prerequisite: AE 311.*

**AE 341 Introduction to Aerodesign 1:3:0:2**

Consideration of the nature of design synthesis and analysis as it pertains to aerospace vehicles. Qualitative and quantitative aspects of feasibility, design methodology, and modeling.

**AE 342 Aircraft Design I 2:3:0:3**

Preliminary design of commercial jet transport. Development of aerodynamic configuration, power plant selection, fuselage lay-out, weight and balance estimation. Performance, stability analyses, airload estimations. *Prerequisite: AE 311.*

**AE 343 Aircraft Design II 2:3:0:3**

Structural design of airplane wings based on specifications and aerodynamic requirements. Discussions of construction materials, forming, fasteners, fittings. Structural arrangement of landing gear, fuselage, stress analysis. *Prerequisite: AE 342.*

**AE 344 Spacecraft Design** 2:3:0:3

Design 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: AE 251.*

**AE 349 Fluids Laboratory I** 1:3:0:2

Laboratory experiments in the area of incompressible inviscid and viscous flows. Measurement techniques, conservation laws, boundary layers. *Prerequisite: AE 231.*

**AE 350 Fluids Laboratory II** 0:3:0:1

Laboratory experiments in the area of inviscid and viscous flows. Measurement Techniques: hot wire and laser Doppler anemometry. Supersonic flows, shock waves, unsteady flows. *Prerequisite: AE 232, AE 349.*

**AE 381-382 Senior Honors Work in Aerospace Engineering I,II**

*Credit To be arranged.*

Independent project undertaken by qualified honors students in aerospace engineering resulting in a written report. Credit may be awarded toward technical elective requirement. *Adviser approval required. Consultation with adviser well in advance of registration is recommended.*

**AE 391-392 Guided Studies in Aerospace Engineering I,II**

*Credit to be arranged.*

Guided readings in specific subject areas for qualified students in aerospace engineering. *Adviser approval required.*

**GRADUATE COURSES**

**AE 651 Advanced Dynamics I**

2½:0:0:3

Kinematics and dynamics of a particle in space; translating and rotating frames of reference. Systems of particles; plane motion of rigid bodies. Two-body central force problem. LaGrange equations

with holonomic and nonholonomic constraints; applications. **Also listed under ME 651.** *Prerequisite: AE adviser's approval.*

**AE652 Advanced Dynamics II**

2½:0:0:3

General motions of rigid bodies, Euler's equations, gyroscopic motions and stability, impulsive motions, linear oscillations of two-degree and n-degree of freedom systems, matrix formulations, applications, variational principles. *Prerequisite: AE 651. Also listed under ME 652.*

**AE 682 Aero- and Hydroelasticity**

2½:0:0:3

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: AE adviser's approval.*

**AE 704 Aerothermochemistry**

2½:0:0:3

Fundamentals of chemical thermodynamics, fluid dynamics and chemical kinetics. Applications to combustion and emission phenomena, fluid lasers, plasmas and hypersonics. *Prerequisite: ME 741.*

**AE 731 Analytical Methods in Thermal and Fluid Mechanics**

2½:0:0:3

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 transform techniques in convection and conduction. *Prerequisite: AE adviser's approval.*

**AE 732 Computational Methods in Thermal and Fluid Mechanics**

2½:0:0:3

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: AE adviser's approval. Also listed under ME 715.*

**AE 740 Principles of Fluid Dynamics**

2½:0:0:3

Conservation laws of mass momentum and energy. Elements of potential theory. Applications of inviscid flow to simple internal and external geometries; differential approach to fluid dynamic problems; thin airfoil theory. *Prerequisite: AE adviser's approval.*

**AE 741 Compressible Flow** 2½:0:0:3

Subsonic, transonic and supersonic flows over two dimensional and axisymmetric bodies. Shock wave development in both one-dimensional unsteady and two-dimensional steady flow systems. Internal and external flows are considered. *Prerequisite: AE adviser's approval.*

**AE 742 Viscous Flow** 2½:0:0:3

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: AE adviser's approval.*

**AE 743 Turbulent Flow** 2½:0:0:3

General theories of turbulence, Reynolds Transport theorem, turbulent heat and mass transfer, instability, transition, statistical approach to turbulence, mathematical modeling, experimental methods, analysis of turbulent external flows; jets, wakes, mixing layers, turbulence in boundary flows. *Prerequisite: AE 742.*

**AE 744 Viscous Compressible Flow**

2½:0:0:3

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: AE 741 and AE 742.*

# AEROSPACE ENGINEERING

## AE 746 Fluid Dynamics of Rotating Machinery 2 1/2:0:0:3

Methods of analysis of flow in rotating machines. Cascades, performance, radial equilibrium, secondary flows, viscous flows. Supersonic and transonic flows in compressors and turbines. *Prerequisite:* AE 740 and AE 741.

## AE 755 Experimental Methods in Thermal and Fluid Mechanics 2 1/2:0:0:3

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:* AE adviser's approval.

## AE 759 Special Topics: Fluid Mechanics 2 1/2:0:0:3

Topics of particular current interest in fluid mechanics. *Prerequisite:* AE adviser's approval.

## AE 801 Trajectories and Orbits 2 1/2:0:0:3

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:* AE adviser's approval.

## AE 803 Vehicle Dynamics I 2 1/2:0:0:3

Atmospheric flight mechanics of airplanes, quasisteady and dynamic performance in various flight regimes, energy methods. Space vehicles, partial motion in central force field, launch and re-entry trajectories. Land and seaborne vehicles: automobile, tracked vehicles, ship and GEM vehicles. *Prerequisite:* AE adviser's approval.

## AE 810 Theory of Propulsion 2 1/2:0:0:3

Principles of modern high-speed propulsion based on chemical energy sources. Air-breathing engines, combustion thermodynamics, flows with chemical reactions, thermochemistry of solid and liquid rocket engines. Engineering parameters in engine design. *Prerequisite:* AE adviser's approval.

## AE 819 Special Topics: Aeronautics and Astronautics 2 1/2:0:0:3

Topics of particular current interest in aeronautics and astronautics. *Prerequisite:* AE adviser's approval.

## AE 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.

## SEMINAR, PROJECTS, THESIS AND DISSERTATION

## AE 971-972 Seminar in Aeronautics and Astronautics 0

Recent developments through lectures by representatives from industry, research, educational institutions. Discussions from floor. Satisfactory attendance required of master's students for two semesters; four additional semesters required of Ph.D. students.

## AE 996 Project each 3 units

Engineering project pursued with guidance of faculty member. Project titles submitted in writing to department head and adviser appointed for the project. May be extended to thesis with project adviser's recommendation. Credit only upon completion of project. Reregistration fee: 3-unit charge. *Prerequisite:* degree status.

## AE 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 AE 996, on recommendation of project adviser. Continuous registration required. Maximum of twelve units of AE 996-997 counted toward degree. Reregistration fee: 3-unit charge. *Prerequisite:* AE 996 or AE adviser's approval.

## AE 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.

## THE FOLLOWING GRADUATE COURSES ARE OFFERED IRREGULARLY IN RESPONSE TO STUDENT DEMAND:

- AE 623-624 Computational Methods in Mechanical & Aerospace Engineering I & II
- AE 714 Radiation Gas Dynamics
- AE 745 Hydrodynamics
- AE 748 Dynamics of Rarefied Gases
- AE 749 Magnetofluid Dynamics
- AE 750 Ocean Waves and Tides
- AE 751-752 Aerodynamics of Urban Environment I & II
- AE 753-754 Wave Turbulence, I & II
- AE 802 Space Mechanics
- AE 804 Vehicle Dynamics II
- AE 806 Physics of the Atmosphere
- AE 811 Engine-Airplane Integration
- AE 812 Helicopter Theory

**FACULTY**

**Pasquale M. Sforza**, Professor and Head of Aerospace Engineering  
B.Ae.E., M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Theoretical and experimental fluid dynamics, aircraft and engine design*

**Anthony E. Armenakas**, Professor  
B.S., Georgia Institute of Technology; M.S., Illinois Institute of Technology; Ph.D., Columbia University  
*Dynamic analysis of structures, fracture, wave propagation, numerical techniques*

**Robert J. Cresci**, Research Professor  
B.Ae.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn  
*Gas dynamics, heat and mass transfer, industrial aerodynamics*

**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*

**James Bentson**, Industry Associate Professor  
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Computational methods, hydrodynamics, vehicle dynamics*

**Morris P. Isom**, Associate Professor  
A.B., Harvard University; M.S., Massachusetts Institute of Technology; Ph.D., Princeton University  
*Acoustics, gas dynamics, applied mathematics*

**Iraj M. Kalkhoran**, Assistant Professor  
B.S., M.S., Ph.D., The University of Texas at Arlington  
*Gas dynamics, high speed flows, wind tunnel testing, shock tubes*

**M. Volkan Otugen**, Assistant Professor  
B.S., Technical University of Istanbul, M.S., Ph.D., Drexel University  
*Experimental and theoretical fluid mechanics, unsteady and turbulent flows, optical diagnostics, combustion aerodynamics*

**Gabriel Oyibo**, Associate Professor  
B.Eng.(Aero) Imperial College, Ph.D., Rensselaer Polytechnic Institute  
*Aeroelasticity, unsteady aerodynamics, transonic flow*

**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*

**EMERITUS FACULTY**

**Vito D. Agosta**, Professor Emeritus  
B.M.E., Polytechnic Institute of Brooklyn, M.S., University of Michigan, Ph.D., Columbia University

**Martin H. Bloom**, Institute Professor Emeritus  
B.M.E., M.S., Ph.D., Polytechnic Institute of Brooklyn

**Joseph Kempner**, Professor Emeritus  
B.Ae.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

**Samuel Lederman**, Professor Emeritus  
Dipl. Ing., Technical University of Munich (Germany);  
M.E.E., Polytechnic Institute of Brooklyn

**Morris Morduchow**, Professor Emeritus  
B.A., Brooklyn College; B.A.E., M.Ae.E., D.Ac.E.,  
Polytechnic Institute of Brooklyn

**Gino Moretti**, Professor Emeritus  
Ph.D., University of Turin (Italy)

**Sebastian V. Nardo**, Professor Emeritus  
B.M.E., M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

**Sharad A. Patel**, Professor Emeritus  
B.Sc., Barnes Hindu University (India); M.Ae.E., Ph.D.,  
Polytechnic Institute of Brooklyn

**ADJUNCT FACULTY**

**Martin Goldberg**, Adjunct Professor  
B.S., N.Y.U.; M.S., University of Buffalo, Ph.D., Rensselaer Polytechnic Institute  
*Structural mechanics*

**Robert S. Levy**, Adjunct Associate Professor  
B.M.E., City College of New York; M.M.E., Ph.D., Polytechnic Institute of Brooklyn  
*Airplane design*

# 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 desalination 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 sound foundation in science and the engineering sciences and builds on this a strong and

integrated set of courses in chemical engineering. Thorough instruction is given in chemistry, physics, mathematics and in the engineering sciences basic to the understanding of physical and chemical operations and processes. Courses in engineering science include engineering thermodynamics, reaction kinetics, process dynamics, fluid mechanics, heat transfer and mass transfer.

The chemical engineering curriculum provides a background that enables the graduate to select a professional career from an extremely broad spectrum of opportunities. Graduates 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 electives.

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

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 120, CH 152, CH 220, CH 221, CH 252 and CH 261; 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.

## Typical Course of Study for the Bachelor of Science Degree in Chemical Engineering

### FRESHMAN YEAR

No.	Subject	Hours/Week			
		Cl	Lab.	Rec.	Cr.
<b>First Semester</b>					
MA 106	<i>Calculus I</i>	4	0	1	4
CS 200	<i>Introduction to Programming Methodology</i>	3	0	0	3
CM 101	<i>General Chemistry I</i>	0	0	0	2 1/2
CM 111	<i>General Chemistry Lab I</i>	0	1 1/2	0	1 1/2
HU 101	<i>Writing and the Humanities I</i>	3	0	0	3
EG 101	<i>Introduction to Engineering</i>	1	3	1	3
SL 101	<i>Freshman Seminar</i>	1	1	0	0
					16

### Second Semester

MA 107	<i>Calculus II</i>	4	0	1	4
PH 107	<i>Mechanics</i>	4	0	0	3
CM 102	<i>General Chemistry II</i>	3	0	0	2 1/2
CM 112	<i>General Chemistry Lab II</i>	0	1 1/2	0	1 1/2
EG 102	<i>Introduction to Engineering Design</i>	1	3	1	3
SS 104	<i>Main Themes in Contemporary World History</i>	3	0	0	3
or					
HU 200	<i>Writing and the Humanities II</i>				3
					16

### SOPHOMORE YEAR

#### First Semester

MA 108	<i>Differential Equations &amp; Numerical Methods</i>	3	0	1	3
PH 108	<i>Electricity, Magnetism &amp; Fluids</i>	3	0	1	3
PH 118	<i>Physics Laboratory I</i>	0	1 1/2	0	1 1/2
CH 120	<i>Chemical Process Analysis</i>	3	0	0	3

CM 122	<i>Organic Chemistry I</i>	3	0	0	3
CM 124	<i>Organic Chemistry Lab I</i>	5	0	0	2
HU 200	<i>Writing and the Humanities II</i>	3	0	0	3
or					
SS 104	<i>Main Themes in Contemporary World History*</i>				17/

**Second Semester**

MA 109	<i>Multidimensional Calculus</i>	3	0	1	3
HU 110	<i>Professional Report 2 Writing</i>	3	0	0	3
CH 152	<i>Chemical Engineering Thermodynamics I</i>	3	0	0	3
CM 161	<i>Physical Chemistry I</i>	3	0	0	3
CM 123	<i>Organic Chemistry II</i>	3	0	0	3
PH 109	<i>Waves, Optics and Thermodynamics</i>	3	0	2	3
PH 119	<i>Physics Laboratory II</i>	0	1/	0	7/

17/

18/

**JUNIOR YEAR**

**First Semester**

CH 220	<i>Transfer Operations I</i>	4	0	0	4
CH 252	<i>Chemical Engineering Thermodynamics II</i>	3	0	0	3
CM 162	<i>Physical Chemistry II</i>	3	0	0	3
	<i>Technical Elective*</i>	X	X	X	3
	<i>Hum./Soc. Sci. Elective*</i>	0	0	0	3

16

**Second Semester**

CH 221	<i>Transfer Operations II</i>	4	0	0	4
CH 261	<i>Multistage Separation Processes</i>	3	0	0	3
EE 370	<i>Principles of Electrical Eng.</i>	3	0	0	3
EE 374	<i>Instrumentation Laboratory</i>	0	3	0	1
MT 305	<i>Eng. Properties of Materials</i>	3	0	0	3
	<i>Hum./Soc. Sci. Elective*</i>	0	0	0	3

**SENIOR YEAR**

**First Semester**

CH 301	<i>Chemical Eng. Laboratory I</i>	0	6	0	2
CH 322	<i>Chemical Reactor Engineering</i>	3	0	0	3
CH 351	<i>Process Dynamics &amp; Control</i>	2	3	0	3
CH 361	<i>Process Design I</i>	3	0	0	3
	<i>Technical Elective*</i>	X	X	X	3
	<i>Hum./Soc. Sci. Elective*</i>	3	0	0	3

17

**Second Semester**

CH 302	<i>Chemical Eng. Laboratory II</i>	0	6	0	2
CH 372	<i>Engineering Polymeric Materials</i>	3	0	0	3
CH 362	<i>Process Design II</i>	3	0	0	3
	<i>Technical Elective*</i>	X	X	X	4
	<i>Hum./Soc. Sci. Elective*</i>	3	0	0	3

18

\*Consult the "UNIVERSITY DEGREE REQUIREMENTS" section of the catalog for variations in the mathematics and humanities sequence which may result based upon placement examination outcomes.

Students taking HU 200 in Freshman second semester takes SS 104 in Sophomore first semester. Students taking SS 104 in Freshman second semester take HU 200 in Sophomore first semester.

\*ESL students must take HU 200 before taking SS 104.

\*Technical electives must meet the requirements described below.

HU/SS electives must meet the concentration requirements described in the "UNIVERSITY DEGREE REQUIREMENTS" section of the catalog.

**ELECTIVES**

Elective courses are chosen in consultation with the chemical engineering undergraduate adviser according to the following guidelines:

- a. A total of 15 credits of Humanities and Social Science electives are required. Consult the "UNIVERSITY DEGREE REQUIREMENTS" section of the catalog for details.
- b. A total of 10 credits of technical electives are necessary. In fulfilling this requirement the student must choose 3 credit hours of mathematics, 3 credit hours of chemistry or bio-sciences, and 4 credit hours of chemical engineering from an approved list available in the chemical engineering office.

**GRADUATE PROGRAMS**

Graduate programs in chemical engineering are designed to introduce students to advanced designs, research and development. The Department of Chemical Engineering offers graduate pro-

grams 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 which is described in a separate section of this catalog.

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 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 list of requirements for full time study:

1. Required Subjects		Credits
CH 631	<i>Transport Phenomena I</i>	3
CH 632	<i>Transport Phenomena II/3</i>	
CH 772	<i>Thermodynamics II</i>	3
CH 781	<i>Chemical Reactor Analysis and Design</i>	3
CH 821	<i>Process Dynamics and Control</i>	3
CH 991/	<i>Seminar in Chemical</i>	
992	<i>Engineering</i>	0

**2. Electives: 3 courses**

At least two electives must be chosen from CH 600-CH 928 while the third one may be chosen from another science or engineering department with the approval of the graduate adviser in chemical engineering.

# CHEMICAL ENGINEERING

3. CH 997 Master's Thesis	$\frac{12}{36}$
Total	36

Part time students can choose between the above program and the *Guided Study Option* which includes the following requirements:

1. Required subjects: as above	15
--------------------------------	----

2. Electives: 5 courses	15
At least two electives must be chosen from CH 600 - CH 928 while the other three may be chosen from other science or engineering departments with the approval of the graduate adviser in chemical engineering.	

3. CH 902 Guided Study in Chemical Engineering	$\frac{6}{36}$
Total	36

To meet graduation requirements, students must have an overall B average in all courses (excluding M.S. Thesis or Guided Study Project) and must not obtain more than two grades of C in required subjects.

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

Programs of study are planned individually with each 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 a 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 and present a doctoral dissertation.

Each candidate for the doctorate must complete a minimum of 90 units (credits) of academic work past the Bachelor's degree, including a minimum of 48 units of dissertation research. Although the student may elect to take more than 48 units of Ph.D. Thesis, only 48 of those units can be counted in the required 90 units. Furthermore, of those 48 units at least 36 must be taken beyond M.S. Thesis and at Polytechnic University. A minimum of 24 graduate units beyond the Bachelor's Degree (not

including Ph.D. or M.S. Thesis units) are required in Chemical Engineering subjects, of which at least 9 must be taken at Polytechnic in the required subjects. A minor is required within a science or engineering department and must consist of at least 9 units taken at the Polytechnic. The minor must meet the approval of the graduate adviser in chemical engineering. Attendance is required at Chemical Engineering Seminars for at least four semesters. To meet graduation requirements, students must have an overall B average in all courses, excluding Thesis, and must not obtain more than three grades of C in required subjects.

Candidates for the degree of Doctor of Philosophy in Chemical Engineering are to plan their programs in accordance with the following requirements:

1. Required Subjects	Units
CH 631 <i>Transport Phenomena I</i>	3
CH 632 <i>Transport Phenomena II</i>	3
CH 771 <i>Thermodynamics I</i>	3
CH 772 <i>Thermodynamics II</i>	3
CH 781 <i>Chemical Reactor Design I</i>	3
CH 821 <i>Process Dynamics and Control</i>	3
CH 991/992 <i>(2 yrs) Seminar in Chemical Engineering</i>	0

2. Electives: 5 courses, of which at least two must be in chemical engineering subjects	15
---	----

To be chosen in conference with the graduate adviser in Chemical Engineering.

3. Minor: 3 courses	9
---------------------	---

A minor must be taken from another science or engineering department with the approval of the graduate adviser in Chemical Engineering.

4. CH 999 Ph.D. Thesis	48
------------------------	----

Up to twelve units of Master's Thesis can be included here.	90
---	----

## UNDERGRADUATE COURSES

CH 120 <b>Chemical Process Analysis</b>	3:0:0:3
---	---------

Introduction to chemical processes and process synthesis and design. Flow

sheets, material balances, recycle, and properties of materials. Applications of computer methods in solving chemical engineering problems. *Prerequisite: adviser's approval.*

CH 152 <b>Chemical Engineering Thermodynamics I</b>	3:0:0:3
---	---------

Thermodynamic principles of chemical processes. First law of Thermodynamics. Energy balances for closed and open systems. Combined energy and mass balances. Humidity and psychrometric charts. Heat capacities and heats of reaction. Equations of state for real fluids. Introduction to the second law of Thermodynamics. *Prerequisite: CH 120.*

CH 220 <b>Transfer Operations I</b>	4:0:0:4
-------------------------------------	---------

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 152 and MA 109 or adviser's approval.*

CH 221 <b>Transfer Operations II</b>	4:0:0:4
--------------------------------------	---------

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 252 <b>Chemical Engineering Thermodynamics II</b>	3:0:0:3
--	---------

Thermodynamics analysis of cyclical processes. Application of First and Second Law for real fluids with equations of state. Ideal and non-ideal mixtures. Partial molar and excess properties of mixtures. Heats of mixing and enthalpy-concentration diagrams. Phase equilibrium calculations at low and elevated pressures by computer procedures. Chemical reaction equilibria. *Prerequisites: CM 161 and CH 152 or adviser's approval.*

**CH 261 Multistage Separation Processes** 3:0:0:3

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 252, or adviser's approval.*

**CH 301-302 Chemical Engineering Laboratory I, II** each 0:6:0:2

Experimental studies in chemical engineering. Unit operations, transport processes, thermodynamics, reaction kinetics, process instrumentation, process dynamics and controls. Design and conduct of experiments, interpretation of results, preparation of engineering reports. Data analyses done with computers. *CH 301 prerequisites: CH 261 and CH 221. CH 302 prerequisites: CH 301, CH 322 and CH 351.*

**CH 322 Chemical Reactor Engineering** 3:0:0:3

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 252 or instructor's permission.*

**CH 351 Process Dynamics and Control** 2:3:0:3

Dynamic simulation of chemical processes. Frequency response techniques. Design of feedback and feedforward controllers. Introduction to nonlinear control. Self study laboratory using IBM's Advanced Control System (ACS). *Prerequisites: CH 221, CH 261, MA 109 or adviser's approval.*

**CH 361 Process Design I** 3:0:0:3

Syntheses and designs of chemical processes, with considerations of site and process selections, process economics, materials of construction, data requirements and acquisition flowsheeting and

subsystems. Computer utilized. Case studies. *Prerequisite: CH 261 and Co/Prerequisite: CH 351.*

**CH 362 Process Design II** 3:0:0:3

Design of large chemical process systems, with special emphasis on more complex, integrated process schemes and systems optimization. *Prerequisites: CH 322 and CH 361.*

**CH 372 Engineering Polymeric Materials** 3:0:0:3

Processing, structure, properties and applications of polymers and their composites as engineering materials. Fundamentals of processing and morphology of polymers. Basic concepts of viscoelasticity, fracture behavior, and thermal and electrical properties of polymers and their composites. *Prerequisites: CM 162 or CH 322, CM 123 and CM 124, MT 305.*

**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 391-392 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 396 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 615 Applied Mathematics in Chemical Engineering** 2 1/2:0:0:3

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

**CH 631-632 Transport Phenomena I, II** each 2 1/2:0:0:3

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 672 Fundamentals of Biochemical Engineering\*** 2 1/2:0:0:3

Kinetics of enzymatic reactions. Transport phenomena in microbial systems. Designs and analyses of biochemical reactors. Principles of natural product isolations. Genetic engineering, and chemical processes. *Prerequisite: instructor's permission.*

## CHEMICAL ENGINEERING

### CH 752 Air Pollution Engineering Control\* 2½:0:0:3

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<sub>x</sub>, SO<sub>x</sub>, CO, etc.) and of aerosols and other particulates. *Prerequisite: adviser's approval. Also listed under CE 758.*

### CH 771 Chemical Engineering Thermodynamics I

Laws of thermodynamics, conditions for thermodynamic equilibria; use of equations of state and the principle of corresponding states to determine changes in thermodynamic properties for pure substances and mixtures. Chemical potentials, standard states, ideal solutions, introduction to chemical and phase equilibria. *Prerequisite: CH 252 or equivalent.*

### CH 772 Chemical Engineering Thermodynamics II 2½:0:0:3

Advanced treatment of chemical and phase equilibria, phase rules, Gibbs-Duhem equation, non-ideal solutions; stability of thermodynamic systems, osmotic pressures, surface tensions, thermodynamic equilibria in potential fields; introduction to irreversible thermodynamics. *Prerequisite: CH 771 or equivalent.*

### CH 781 Chemical Reactor Design I 2½:0:0:3

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 non-ideal flow; fixed-bed, fluidized-bed and multiphase reactors. *Prerequisite: CH 322.*

### CH 821 Process Dynamics and Control 2½:0:0:3

Instrumentation and control of chemical processes from the view-point of systems engineering. Unsteady state behavior of chemical engineering systems. Analyses of closed-loop feedback systems for control of variables of chemical processes equipment. *Prerequisite: CH 351 or equivalent.*

### CH 862 Rheology of Non-Newtonian Fluids\* 2½:0:0:3

Classifications of non-Newtonian viscoelastic fluids. Derivations of rheological equations of state from continuum mechanics points of view. Molecular viscoelastic theories: random-coil and network theories. Experimental characterizations of non-Newtonian fluids: steady and dynamic experiments, measurements of normal stress differences in shear flow. Engineering applications to polymer processing operations. *Prerequisites: CH 631, MA 531 and MA 532 or equivalent.*

### CH 900-901 Selected Topics in Chemical Engineering each 2½:0:0:3

Topics of special current interest in chemical engineering, as announced in advance of a particular semester offering. *Prerequisite: adviser's approval.*

## PROJECTS, THESES 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 practices 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 design. 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 the 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

Theses for master's degree in polymer science and engineering should give results of original investigations of problems in the chemistry and chemical engineering of polymeric materials. Theses may involve experimental research, theoretical analyses, process designs or combinations thereof. Master's degree candidates required to submit four typewritten unbound thesis copies to advisers before or on the seventh Wednesday before commencement. *Prerequisite: degree status.*

### CH 989 Dissertation for Degree of Doctor of Philosophy in Polymer Science and Engineering 30 units, each 3 units

See description for CH 999. A wide variety of problems may be selected from topics in polymer science and engineering. *Prerequisite: see CH 999.*

### CH 991-992 Seminars in Chemical Engineering nc

Recent developments in chemical engineering are presented through lectures given by engineers from industry, research and educational institutions, by staff members and by qualified graduate students. Required for two semesters of all graduate students seeking degrees.

### 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 investigation of problems in chemical engineering or application of physical, chemical or other scientific principles to chemical engineering. Theses may involve experimental research, theoretical analyses or process designs or combinations thereof. Master's degree candidates required to submit four typewritten unbound thesis copies to advisers before or on the seventh Wednesday prior to commencement. *Prerequisite: degree status.*

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

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.*

**THE FOLLOWING GRADUATE COURSES ARE OFFERED IRREGULARLY IN RESPONSE TO STUDENT DEMAND**

- CH 611 Unit Processes of Chemical Technology
- CH 612 Chemical Processes and Project Evaluations
- CH 615 Applied Mathematics in Chemical Engineering
- CH 641 Particle Transport Processes
- CH 721 Mass Transfer Operations
- CH 782 Process Heat Transfer
- CH 782 Chemical Reactor Design II
- CH 784 Heterogeneous Catalysis
- CH 791 Modern Electrochemistry
- CH 819 Machine Computations in Chemical Engineering
- CH 851 Process Design & Synthesis I
- CH 852 Process Design & Synthesis II

**FACULTY**

**Allan S. Myerson**, Joseph J. and Violet J. Jacobs Professor and Head, Department of Chemical Engineering B.S., Columbia University; M.S., Ph.D., University of Virginia *Crystallization, 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*

**T.K. Kwei**, Professor of Chemistry and Chemical Engineering B.S., National Chiao-Tung University (China); M.S., University of Toronto; Ph.D., Polytechnic Institute of Brooklyn *Polymer-polymer miscibility, phase relationships in polymers*

**Eli M. Pearce**, University Professor, Director, Polymer Research Institute B.S., Brooklyn College; M.S., New York University; Ph.D., Polytechnic Institute of Brooklyn *Polymer synthesis and degradation*

**Robert J. Farrell**, Associate Professor of Chemical Engineering B.S., Polytechnic Institute of Brooklyn; M.S., University of Connecticut, Ph.D., Polytechnic Institute of New York. *Process simulation, control, and optimization, chemical process design.*

**Jovan Mijovic**, Associate Professor of Chemical Engineering B.S., University of Belgrade; M.S., Ph.D., University of Wisconsin (Madison); *Modelling of processing of polymers and polymer composites, in-situ monitoring of processes, structural relaxation in the glassy state.*

**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*

**Walter P. Zurawsky**, Associate Professor of Chemical Engineering B.A., Temple University; M.S., Ph.D., University of Illinois *Plasma polymerization, mass transfer in membranes.*

**Nitash P. Balsara**, Assistant Professor of Chemical Engineering B.S., Indian Institute of Technology (Kanpur); M.S., Clarkson University; Ph.D., Rensselaer Polytechnic Institute *Polymer phase behavior, scattering (light and neutrons) and diffusion*

**Lawrence R. Dodd**, Assistant Professor of Chemical Engineering B.S., North Carolina State University; M.S., Ph.D., University of Delaware *Molecular modelling of macromolecular systems, computer simulations, thermodynamics.*

**EMERITUS FACULTY**

**Robert F. Benenati**, Professor Emeritus of Chemical Engineering B.Ch.E., M.Ch.E., Ph.D., Polytechnic Institute of Brooklyn *Computer application to process design, packed and fluidized beds, heat transfer.*

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

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

**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., Polytechnic Institute of Brooklyn *Unit operations, laboratory information*

# CHEMISTRY

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 interdisciplinary 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 stimuli 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.

The department also offers a joint graduate program with the Department of Chemical Engineering.

## POLYMER SCIENCE AND ENGINEERING

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.)

## UNDERGRADUATE PROGRAMS

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.

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

	Credits
CM 101, 102, 108, 111, 112, 119, 120, 122-125, 161, 162, 177, 501, 504	41
Advanced Chemistry	9
*Thesis Research (CM 390-394)	10
CS 200	3
MA 106-109, one elective	17
PH 107-109, 118-119	10

The minimum of 134 credits required for the degree of bachelor of science in chemistry includes a minimum of 33 credits in humanities and social sciences.

At least two semesters of a foreign language (French, German or Russian) are strongly recommended.

\*Students registering for thesis research are required to submit a written report prior to graduation. Students may elect a no thesis option (such degree programs will not be certified by the American Chemical Society) and select ten credits of advanced chemistry courses in consultation with an adviser.

## Curriculum for the Bachelor of Science Degree in Chemistry

### FRESHMAN YEAR

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
<b>First Semester</b>				
CM 101	<i>General Chemistry I</i>	2 1/2	0	2 1/2
CM 111	<i>General Chemistry Lab I</i>	0	1 1/2	1 1/2
CS 200	<i>Programming Methodology</i>	4	0	3
MA 106*	<i>Calculus I</i>	5	0	4
HU 101	<i>Writing and the Humanities I</i>	3	0	3
or HU 103*				
HU or SS	<i>Elective</i>	3	0	0
SL 101	<i>Freshman Seminar</i>	0	1	0
				16

### Second Semester

CM 102	<i>General Chemistry II</i>	2 1/2	0	2 1/2
CM 112	<i>General Chemistry Lab II</i>	0	1 1/2	1 1/2
MA 107	<i>Calculus II</i>	5	0	4
PH 107	<i>Mechanics</i>	4	0	3
HU 200	<i>Writing and the Humanities II</i>	3	0	3
or SS 104	<i>Contemporary World History</i>			
HU or SS	<i>Elective</i>	3	0	3
				16

### SOPHOMORE YEAR

#### First Semester

CM 122	<i>Organic Chemistry I</i>	3	0	3
CM 124	<i>Organic Chemistry Lab I</i>	1 1/2	5	2
MA 108	<i>Diff. Eqns. &amp; Num. Meth.</i>	3	0	3
PH 108	<i>Elec., Magn., &amp; Fluids 4</i>	0	0	3

**REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE**

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 or guided studies) submitted for a master's degree. Programs must include the following core courses:

No.	Subject	Units
CM 601	<i>Inorganic Chemistry</i>	4/
CM 703	<i>Chemical Physics I</i>	4/
	<i>or</i>	
CM 704	<i>Chemical Physics II</i>	4/
CM 802	<i>Applied Spectroscopy</i>	4/
	<i>or</i>	
CM 907	<i>Organic Spectroscopy</i>	
CM 903	<i>Advanced Organic Chemistry I</i>	4/
	<i>or</i>	
CM 904	<i>Advanced Organic Chemistry II</i>	

Upon the approval of the Department Head, students may elect CM 771 (Introductory Polymer Chemistry) in place of CM 601.

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. Students are strongly encouraged to take CM 501, Chemical Literature.

PH 118	<i>Physics Laboratory I</i>	0	1 1/2	7/2
SS 104	<i>Contemporary World History</i>	3	0	3
or HU 200	<i>Writing and the Humanities II</i>			
HU 110	<i>Prof. Report Writing</i>	3	0	3
				17.5

**Second Semester**

CM 123	<i>Organic Chemistry II</i>	3	0	3
CM 125	<i>Organic Chemistry Lab II</i>	7/2	5	2
CM 161	<i>Physical Chemistry I</i>	3	0	3
MA 109	<i>Multidimen. Calculus</i>	3	0	3
PH 109	<i>Waves, Optics, &amp; Thermo.</i>	4	0	3
PH 119	<i>Physics Laboratory II</i>	0	1 1/2	7/2
HU or SS	<i>Elective</i>	3	0	3
				17.5

**JUNIOR YEAR**

**First Semester**

CM 162	<i>Physical Chemistry II</i>	3	0	3
CM 177	<i>Physical Chemistry Lab</i>	7/2	5	2
CM 504	<i>Chemical Lab Safety</i>	1	0	1
MA	<i>Elective</i>	3	0	3
HU or SS	<i>Elective</i>	3	0	3
	<i>Electives</i>	6	0	6
				18

**Second Semester**

CM 108	<i>Inorganic Chemistry</i>	3	0	3
CM 119	<i>Analytical Chemistry</i>	3	0	3
CM 120	<i>Analytical Chemistry Lab</i>	0	6	2
CM 501	<i>Chemical Literature</i>	1	0	1
HU or SS	<i>Elective</i>	3	0	3
	<i>Technical Elective</i>	3	0	3
	<i>Elective</i>	3	0	3
				18

**SENIOR YEAR**

**First Semester**

CM 390-91	<i>Undergraduate research</i>	0	12	4
CM	<i>Electives</i>	6	0	6
HU or SS	<i>Elective</i>	3	0	3
	<i>Elective</i>	3	0	3
				16

**Second Semester**

CM 392-94	<i>Undergraduate research</i>	0	18	6
CM	<i>Elective</i>	3	0	3
HU or SS	<i>Elective</i>	3	0	3
	<i>Elective</i>	3	0	3
				15

Total credits for graduation 134

\* Placement by examination

Students are strongly urged to select areas of concentration (such as literature, communications, the arts or philosophy 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. A minimum of two semesters of French, German or Russian is recommended.

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

Advanced chemistry courses may include any chemistry course numbered 500 or above, as well as CM 201-202 or CM 204.

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.

**GRADUATE PROGRAMS**

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 all basic chemistry courses (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. All applicants are required to take the Graduate Record Examination (General and Chemistry). Applicants whose native language is other than English must score at least 550 on the TOEFL. All teaching assistants must pass HU 521 or an oral examination given by the Chemistry Department. Chemistry graduate students cannot take CM 500 level courses for graduate credit.

## REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

The student selects a research adviser after interviewing a minimum of five faculty members. The student must take the Written Preliminary Examination during the second year. Two attempts are allowed. (After a second failure, the student is dropped from the doctoral program). The student then selects a dissertation committee including the research adviser, major advisers, a minor adviser and at least one other faculty member who monitors the progress of the student through the rest of the program. Within six months after the Written Preliminary Examination, an Oral Preliminary Examination must be completed, where students will present plans and possibly 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 on awarding a Ph.D. is made by the dissertation committee.

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 biochemistry, 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 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:

Course	Title	Units
CM 601	<i>Inorganic Chemistry</i>	4/
CM 703	<i>Chemical Physics I</i>	4/
	or	
CM 704	<i>Chemical Physics II</i>	

CM 802	<i>Applied Spectroscopy</i>	4/
	or	
CM 907	<i>Organic Spectroscopy</i>	
CM 903	<i>Organic Chemistry I</i>	4/
	or	
CM 904	<i>Organic Chemistry II</i>	

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 five major areas in chemistry, i.e., biochemistry, inorganic, organic, physical and polymer.

#### Biochemistry:

CM 601, CM 704, CM 802, CM 903, and at least 9 credits selected from the following: CM 781, CM 790, CM 941-7, CH 672.

#### 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 CM 704, CM 903, CM 904, CM 907 and CM 920.

#### Physical Chemistry:

CM 601, CM 703, CM 704, CM 802; CM 903 or CM 904; either CM 721 and CM 722 or 9 credits selected from PH 663, PH 664, PH 667 or PH 668; and CM 995.

#### Polymer Chemistry:

CM 601, CM 703 or CM 704, CM 802 or CM 907, CM 903 or CM 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 area 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.

5. Research presented in a dissertation.

6. All doctoral students must take CM 504, Chemical Laboratory Safety, prior to registering for thesis research.

7. Students are strongly encouraged to take CM 501, Chemical Literature.

8. Students must be in continuous attendance at department 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.

## UNDERGRADUATE COURSES

### CM 101 General Chemistry I

3:0:0:2/

Chemical equations; chemical conservation laws; stoichiometry; thermochemistry; properties of gases; atomic structure; periodic table; chemical bonding and molecular structure. *Co-requisite:* MA 105 or MA 106.

### CM 102 General Chemistry II

3:0:0:2/

States of matter; chemical thermodynamics and chemical equilibria; kinetics; acid-base chemistry; descriptive inorganic chemistry; introduction to organic chemistry. This course covers some traditional topics plus a considerable emphasis on the properties of materials and their relationship to molecular structure. *Prerequisite:* CM 101 or equivalent.

**CM 108 Inorganic Chemistry** 3:0:0:3  
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 111 General Chemistry Laboratory I** 0:17:0:1  
Laboratory experiments in general chemistry; taken in conjunction with CM 101. Lab fee required. *Pre/Co-requisite:* CM 101.

**CM 112 General Chemistry Laboratory II** 0:17:0:1  
Laboratory experiments in general chemistry; taken in conjunction with CM 102. Lab fee required. *Prerequisite:* CM 111. *Pre/Co-requisite:* CM 102.

**CM 119 Instrumental Methods in Analytical Chemistry** 3:0:0:3  
Theories and applications of instrumental techniques in modern analytical chemistry, including chromatography, spectroscopy (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** 0:6:0:2  
Techniques described in CM 119 applied to various chemical problems stressing physicochemical interpretation of data obtained. Lab fee required. *Prerequisites:* CM 161-162. *Co/Prerequisite:* CM 119.

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

**CM 124 Organic Chemistry Laboratory I** 1/2:5:0:2  
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** 1/2:5:0:2  
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** 3:0:0:3  
Chemical thermodynamics (macroscopic and molecular approach) with applications to solutions, phase and chemical equilibria. Kinetic theory. *Prerequisites:* CM 102, CM 112, MA 108 and PH 108.

**CM 162 Physical Chemistry II** 3:0:0:3  
Electrochemistry; ionic solutions. Solids, liquids, surfaces, high polymers. Chemical kinetics. Relation of bulk properties of matter to atomic and molecular properties. *Prerequisite:* CM 161.

**CM 177 Physical Chemistry Laboratory** 1/2:5:0:2  
Experimental quantitative chemical methods of analytical and physical chemistry, which will include introduction to gravimetric and volumetric quantitative methods, thermodynamics, and chemical kinetics. Computer analysis of experimental data and report writing. Lab fee required. *Co/Prerequisite:* CM 162.

**CM 201 Biochemistry I** 3:0:0:3  
Survey of modern biochemistry with emphasis on current areas of research. Structure-function relationships in proteins. Enzymes and their mechanisms of action. Bioenergetic principles and energy production. Biochemical theories and techniques. *Prerequisites:* CM 123, CM 125 and CM 161, or instructor's permission.

**CM 202 Biochemistry II** 3:0:0:3  
Continuation of Biochemistry I. Principles of intermediary metabolism, ener-

getics, membrane structure and transport; structure and function of DNA and RNA, principles of molecular biology, the immune system, hormonal regulation, cancer. *Prerequisites:* CM 201 and CM 162, or instructor's permission.

**CM 204 Biochemistry Laboratory** 1/2:5:0:2  
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 Undergraduate Research 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 conferences and seminars scheduled as work progresses. A written report is required. Full-time students are expected to register for 10 credits of thesis during senior year. Research (lab) fee required. *Co/Prerequisites:* CM 501 and CM 504.

### GRADUATE COURSES (SPECIAL LISTINGS):

#### *Undergraduate and Graduate*

**CM 501 Chemical Literature** 1:0:0:1  
Programs of lectures, exercises and discussion designed to familiarize students with the chemical literature. Undergraduate students may emphasize topics related to their research. *Prerequisites:* CM 123, CM 125 and CM 162.

**CM 502 Environmental Chemistry** 3:0:0:3  
Chemical properties of pollutants in air, water, soil and hazardous wastes. Effects of chemical pollutants on health. *Prerequisites:* CM 122, CM 124 and CM 161 or instructor's permission. This course does not fulfill requirements for the regular M.S. or Ph.D. degrees in chemistry.

## CHEMISTRY

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

### GRADUATE COURSES

#### INORGANIC CHEMISTRY

**CM 601 Inorganic Chemistry** 3½:0:0:4½  
Theories of bonding in 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 2½:0:0:3

#### PHYSICAL CHEMISTRY

**CM 703 Chemical Physics I** 3½:0:0:4½  
Quantum structures of molecules. Fundamental ideas of quantum mechanics. Applications to atomic and molecular structures and bonding. Approximation methods. Interactions of light and matter. *Prerequisites: undergraduate physical chemistry and physics.*

**CM 704 Chemical Physics II** 3½:0:0:4½  
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 715-717 Advanced Topics in Physical Chemistry** each 2½:0:0:3

**CM 721 Quantum Mechanics for Chemists** 3½:0:0:4½

**CM 722 Statistical Mechanics for Chemists** 3½:0:0:4½

**CM 730-731 Group Theory and its Applications I,II** each 2½:0:0:3

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

**CM 760 Minicomputer Instrumentation for Scientific Research** 1½:2:0:3

#### POLYMER CHEMISTRY

**CM 771 Introductory Polymer Chemistry** 2½:0:0:3  
Synthesis of polymers by step-reaction and addition polymerization; copolymerization; formation of three dimensional networks; block and graft polymers; polymer degradation; characterization of polymers in solution rubber elasticity; polymer crystallization; spectroscopic techniques for polymer study; properties of commercial polymers. *Prerequisites: CM 123, CM 125 and CM 162, or instructor's permission.*

**CM 772 Synthesis of High Polymers** 2½:0:0:3

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. *Prerequisite: CM 771.*

**CM 781 Solution Properties of High Polymers** 2½:0:0:3

Application of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, viscosity, diffusion, ultracentrifugal 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 are discussed. The course is designed to cover both synthetic and biological macromolecules. *Prerequisite: CM 771.*

**CM 782 Macromolecules in Solid States** 2½:0:0:3  
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** 0:4:0:3  
Experiments on free radical and ionic polymerizations, copolymerization; UV/VIS 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** 2½:0:0:3  
Presentation at intervals of various advanced or specialized topics in polymer chemistry.

**CM 790 Biopolymers** 2½:0:0:3  
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 polymers or biochemistry, or minor field requirements in biochemistry. *Pre/Corequisite: CM 941 or consent of instructor.*

#### ANALYTICAL CHEMISTRY

**CM 802 Applied Spectroscopy** 3½:0:0:4½

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.

#### ORGANIC CHEMISTRY

**CM 903 Organic Chemistry I**

3½:0:0:4½

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**

3½:0:0:4½

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**

3½:0:0:4½

Structure elucidation by joint applications of spectroscopic techniques such as proton and carbon-13 magnetic resonance, infrared and mass spectroscopy, and other methods. *Prerequisite: CM 903 or CM 904 or consent of instructor.*

**CM 915 Topics in Physical Organic Chemistry**

2½:0:0:3

**CM 920 Current Aspects of Organic Synthesis**

2½:0:0:3

**CM 921-933 Advanced Topics in Organic Chemistry**

2½:0:0:3

**CM 940 Special Topics in Organic Chemistry**

2½:0:0:3

Topics selected from current research or literature, and approaches to problem solving. *Co/Prerequisite: CM 903 or CM 904.*

**BIOCHEMISTRY****CM 941-942 Biochemistry I,II**

each 2½:0:0:3

In depth studies of biochemistry. Structure and function of biological macromolecules: proteins, nucleic acids, polysaccharides. Enzyme kinetics, mechanism and control. Membrane structure and function. Energy production, transformation and utilization. Regulation of

biochemical systems. Replication, transcription and translation of DNA. Mutagenesis and carcinogenesis. Immune system. *Prerequisite: consent of instructor.*

**CM 943-946 Advanced Topics in Biochemistry**

2½:0:0:3

Selections from the following topics: protein and nucleic acid chemistry; intermediary metabolism; and metabolic regulation. *Prerequisite: CM 941 or consent of instructor.*

**GENERAL COURSES****CM 871-872 Guided 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**

1:0:0:0

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 0:0:1½:1½

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 998 Research in Chemistry***as arranged*

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 thesis: 12 units. Registration for research required each semester consecutively until students have completed adequate research projects and acceptable theses and passed required oral examinations. Research credits registered for each semester reflect realistically time devoted to research. A maximum of 6 units

may be counted towards a Ph.D. in chemistry. Research charge. *Prerequisites: for M.S. candidates, degree status and consent of graduate adviser and thesis director and CM 504.*

**CM 999 Research in Chemistry***as arranged*

Original experimental or theoretical research (undertaken under guidance of a chemistry faculty member), which may serve as basis for degree of doctor of philosophy. Minimum research registration requirements 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 until students have completed adequate research projects and acceptable theses and passed required oral examinations. Number of research credits registered for each semester must reflect realistically time devoted to research. Research fees required. *Prerequisites: completion of Ph.D. preliminary examination in chemistry, 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, responsiveness, and locomotion. Structures and function of living matter at the molecular, cellular and organismal levels must be probed. Biology, chemistry and physics contribute to understanding of living systems.

## CHEMISTRY

### UNDERGRADUATE COURSES

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

**LS 115-116 General Biology Laboratory I, II**  
*0:3:1:2*  
Recitations in relationship to laboratory experiments include discussions of such topics as: cell structure and function; chemical and physical characteristics of living things; unity and diversity of living things; genetics, development, homeostasis, integration and coordination; adaption, evolution, ecology and the biological bases of behavior. Lab fee required. *LS 115 Co/Prerequisite: LS 105. LS 116 Co/Prerequisite: LS 106.*

**LS 103-200 Topics in Biology**  
*as arranged*

**LS 305-307 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. Evaluated on basis of written and oral reports present to faculty and outside project co-sponsors. Faculty conferences and visits required. Open to senior students on approval of departmental adviser. Preplanned experiences provide students with significant exposure to relationships between theoretical information and practical applications. *Prerequisite: senior status or adviser's consent.*

**LS 310 Seminar in Biology** *1 credit*

### GRADUATE COURSES

**LS 561-702 Advanced Topics in Biology**  
*as arranged*  
From time to time, graduate level courses may be offered in Bioethics, Electron Microscopy, Environmental Biology, Neurophysiology, Topics in Neurophysiology, Topics in Neurosciences, and Cytology.

**LS 900 Selected Topics in Biology**  
*2 1/2:0:0:3*

## FACULTY

**Mary K. Cowman**, Chemistry Department Head and Associate Professor of Biochemistry  
B.S., M.S., Ohio University; Ph.D., Case Western Reserve University  
*Solution conformation and interactions of complex carbohydrate polymers; biochemistry of extracellular matrix components*

**John N. Carter**, Research Assistant Professor of Chemistry  
B.S., Ph.D., Polytechnic University  
*Chemical Vapor Deposition, sol chemistry, computers in chemistry*

**Frederick Eirich**, Distinguished Professor of Polymer Chemistry  
Ph.D., University 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**, Professor of Organic Chemistry  
B.S., CCNY; Ph.D., Princeton University  
*Stereochemistry of reactive intermediates, macromolecular stereochemistry, isolation of bio-active plant substances*

**T.K. Kwei**, Professor of Polymer Chemistry  
M.S., National Chiao-Tung University (China); M.S., University of Toronto; Ph.D., Polytechnic Institute of Brooklyn  
*Polymer-polymer miscibility, segmented polyurethanes and unsaturated polyesters, phase relationships in polymer blends, interactions in composites*

**Kalle Levon**, Associate Professor of Polymer Chemistry  
M.Sc., University of Helsinki; Dr. Agr., University of Tokyo  
*Phase separation in polymer blends and solutions, gelation, conductive polymers*

**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  
Ph.D., Purdue University  
*Organic and polymer synthesis, characterizations and applications*

**Eli M. Pearce**, University Professor and Director of the Polymer Research Institute  
B.S., Brooklyn College; M.S., New York University; Ph.D., Polytechnic Institute of Brooklyn  
*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**, Professor of Chemistry  
Dr. Ing. (Prague); D.Sc. (London)  
*Polymer photochemistry, photoresists, image science*

## EMERITUS FACULTY

**Wayne F.K. Schnatter**, Assistant Professor of Organic Chemistry  
B.S. (Chemistry) B.S. (Biology), Rensselaer Polytechnic Institute; M.A., Ph.D., Princeton University  
*Organotransition metal chemistry; synthesis of enantiomerically pure compounds; molecular design; catalyst development*

**Iwao Teraoka**, Assistant Professor of Polymer Chemistry  
B.S., Ph.D. University of Tokyo  
*Polymer solution dynamics, fractionation of polymers*

**Guiliana Tesoro**, Research Professor of Polymer Chemistry  
Ph.D., Yale University  
*Applied polymer science, fiber science, thermal dehydration and flammability of polymers, composites, and polymers for electronics applications*

**Nancy M. Tooney**, Associate Professor of Biochemistry and Assistant Provost for Academic Affairs  
B.S., M.S., SUNY (Albany); Ph.D., Brandeis University  
*Structure and function of proteins and other biopolymers, blood clotting system, fibronectin structure and function, environmental chemistry*

**Otto Vogl**, Herman Mark Professor of Polymer Chemistry  
Ph.D., University of Vienna  
*Polymer synthesis, stereospecific polymerization, functional polymers, polymeric UV stabilizers*

**Ephraim Banks**, Professor Emeritus of Inorganic Chemistry B.S., CCNY; Ph.D., Polytechnic Institute of Brooklyn  
*Chemistry and physics of crystals, solid state reactions and phase transitions*

**Ernest LoebI**, Professor Emeritus of Physical Chemistry  
M.S., Hebrew University; Ph.D., Columbia University  
*Theoretical chemistry, quantum statistical mechanics*

**Herbert Morawetz**, Institute Professor, Professor Emeritus 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.*

# CIVIL 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 management, engineering mechanics, environmental engineering, highway, hydraulics, irrigation and drainage, materials engineering, pipeline, structural, surveying engineering, urban planning and development, urban transportation, water resources planning and management, waterway, port, coastal and ocean engineering.

Civil engineering is a multi-dimensional profession which involves a wide variety of engineering tasks and applications offering a multitude of challenging career opportunities. The wide range of professional careers involve engineering design, construction supervision, urban system planning, engineering management, research, and product technology development.

Many civil engineers pursue their professional careers in private practice as consultants or as employees of major municipal service organizations, government construction and regulatory agencies, transportation authorities, architects and urban planners. Others are employed by construction or manufacturing companies. 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 and other infrastructure networks, improve public services, optimize the use of water and energy resources, upgrade housing and mass transportation systems, and protect the natural environment. Environmental engineering is closely linked to civil engineering but goes beyond the "design and build" function to examine basic problems of scarce natural resources, pollution control and waste disposal.

Transportation planners and engineers design, maintain and operate efficient and cost-effective mass transportation and highway systems.

Many civil, environmental and transportation engineers continue beyond the bachelor's degree to graduate studies and research at the master's, engineer's, and doctoral levels. Others branch out into law, management, planning, and other fields.

## UNDERGRADUATE PROGRAM

The undergraduate program leading to the Bachelor of Science in Civil Engineering is accredited by the Accreditation Board for Engineering and Technology (ABET).

The fundamental sciences of mathematics, physics and chemistry are presented first, together with the principles of computer programming. The relevance of these subjects to engineering is shown in two introductory courses in engineering which include examples of knowledge and applications in various engineering fields and provide hands-on laboratory and design experiences. The basic engineering sciences for civil and environmental engineering are presented next and include engineering measurements, computer techniques and properties of materials such as steel and concrete, soils, and fluids.

The last phase of the program provides the courses with specific professional applications in the planning, analysis, design, and construction of projects. For civil engineering, these projects include buildings and bridges, water supply and wastewater treatment facilities, highways and street systems, and other components of the infrastructure.

Written and verbal skills are developed in introductory English courses and in required exercises in many technical courses. Intellectual horizons are also extended through courses in the humanities and social sciences.

The program prepares students broadly in all major areas of civil and environmental engineering so that graduates can be immediately employed in the profession. The program also provides the basis for proceeding directly to graduate degree programs in civil and environmental engineering or for various pre-professional degrees such as law or management.

## TECHNICAL ELECTIVES

To allow students to broaden their technical knowledge, the curriculum provides 6 technical elective credits of appropriate coursework. Approved technical electives are indicated below, including a number of graduate courses that are suitable for undergraduate students. Senior courses in other departments, and other graduate courses may be chosen, but they require the approval of a departmental adviser.

No.	Technical Electives	Credits
CE 336	<i>Timber and Masonry Structures</i>	3
CE 353	<i>CAD in Civil Engineering</i>	3
CE 606	<i>Bridge Engineering</i>	3
CE 781	<i>Analysis of Public Works</i>	3
CE 726	<i>Computer Applications in Water Resources</i>	3
CE 751	<i>Environmental Health Eng.</i>	3
CE 752	<i>Air Pollution</i>	3
CE 849	<i>Environmental Geotechnology</i>	3
CE 850	<i>Ground Improvement</i>	3
IE 300	<i>Engineering Economy</i>	3

ROTC students should note that 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 adviser according to university and departmental guidelines:

For further information, students should refer to the section of this catalog entitled "Humanities and Social Sciences Requirements for Engineering and Computer Science Majors".

**TRANSFER STUDENTS (Undergraduate)**

Potential transfer students should refer to the University guidelines as shown elsewhere in 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 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 30 credits at Polytechnic with a civil engineering designation as indicated below:

<b>Junior Year</b>	<b>Senior Year</b>
1st term	1st term
CE 322	CE 252
CE 340	CE 317
CE 351	CE 341
2nd term	2nd term
CE 323	CE 332
CE 331	CE 342

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.

**PART-TIME STUDENTS (Undergraduate)**

Prospective students planning to earn a degree on a part-time basis should contact an undergraduate adviser for details about this plan before enrolling. Most upper-level courses for part-time students are offered on an alternate-year basis and may be integrated with the day program using a late afternoon schedule starting at 4 pm. A sample 8-year program is shown for part-time study; courses in the first 3 years of this program, and courses by other departments, are often available only on day schedules.

**Typical Course of Study for the Bachelor of Science Degree in Civil Engineering**

**FRESHMAN YEAR**

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
<b>First Semester</b>				
MA 106	<i>Calculus I</i>	5	0	4.0
CM 101	<i>Gen. Chem. I</i>	3	0	2.5
CM 111	<i>Gen. Chem Lab I</i>	0	1.5	.5
CS 200	<i>Programming Meth.</i>	4	0	3.0
HU 101/3	<i>Writing and the Humanities I (1)</i>	3	0	3
EG 101	<i>Intro to Engineering</i>	2	3	3
SL 101	<i>Freshman Seminar</i>	1	1	0
				16

**Second Semester**

MA 107	<i>Calculus II</i>	5	0	4
CM 102	<i>Gen. Chem II</i>	3	0	2.5
CM 112	<i>Gen. Chem Lab II</i>	0	1.5	.5
PH 107	<i>Mechanics</i>	4	0	3
HU 200	<i>Writing and the Hum. II</i>			
or SS 104	<i>Cont World Hist. (2,3)</i>	3	0	3
EG 102	<i>Intro to Eng. Design</i>	2	3	3
				16

**SOPHOMORE YEAR**

**First Semester**

MA 108	<i>Diff. Equations &amp; Num. Meth.</i>	3	0	3
PH 108	<i>Elect. Magn. &amp; Fluids</i>	4	0	3
PH 118	<i>Phys. Lab for PH 108</i>	0	1.5	.5
HU 200	<i>Writing &amp; Hum. II</i>	3	0	3
or SS 104	<i>Cont World Hist (2,3)</i>			
CE 152	<i>Meas. In Civil Eng.</i>	1.5	1.5	2
ME 111	<i>Eng. Mechanics I</i>	3	0	3
CE 215	<i>Computer Tech in Civil Engineering</i>	1.5	1.5	2
				16.5

**Second Semester**

MA 109	<i>Multidim Calculus</i>	4	0	3
PH 109	<i>Waves, Opt. &amp; Therm</i>	4	0	3
PH 119	<i>Phys Lab for PH 109</i>	3	1.5	.5
HU/SS	<i>Hum/Soc. Sci Elect</i>	3	0	3
HU 110	<i>Prof. Report Writ.</i>	3	0	3
CE 223	<i>Fluid Mechanics</i>	2.5	1.5	3
CE 202	<i>Mech. of Materials</i>	3	0	3
				18.5

# CIVIL ENGINEERING

## JUNIOR YEAR

### First Semester

HU/SS	Hum/Soc. Sci Elect	3	0	3
MA 222	Intro to Prob & Stat	3	0	3
CE 307	Const. Materials	2	3	3
CE 340	Water Resources & Hydraulic Eng	3	0	3
CE 322	Anal. of Struct. I	3	0	3
CE 351	Highway & Transportation Engineering	2	3	3
				18

### Second Semester

HU/SS	Hum/Soc. Sci Elect	3	0	3
CE 232	Soil Mechanics	2	3	3
CE 331	Steel Structures	2	3	3
EE 370	Princ. of Elect. Eng.	3	0	3
CE 323	Anal. of Struct. II	3	0	3
CE 352	Traffic Eng.	3	0	3
				18

## SENIOR YEAR

### First Semester

HU/SS	Hum/Soc. Sci Elect.	3	0	3
CE 252	Reinf. Conc. Struct.	3	0	3
CE 317	Foundations	2	3	3
CE 341	Environmental Eng. I	2	3	3
ME 201	Thermodynamics	3	0	3
	Technical Elective	3	0	3
				18

### Second Semester

HU/SS	Hum/Soc. Sci Elect.	3	0	3
CE 335	Proj. Mgmt for Const.	3	0	3
CE 332	Design of Structural Systems (4)	2	3	3
CE 342	Env. Eng. II	2	3	3
	Technical Elective	3	0	3
				15

Total 136(15)

- (1) Placement by examination
- (2) Students taking HU 200 in Freshman second semester take SS 104 in Sophomore first semester and vice versa
- (3) ESL students must take HU 103 before taking SS 104
- (4) Additional Senior Design Project credits are included in CE 252 and CE 342
- (5) Minimum total credits required for graduation 136 with a minimum GPA of 2.0

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

## FIRST YEAR

No.	Subject	Hours/Week		
		Cl.	Lab.Cr.	
<b>First Semester</b>				
MA 106	Calculus I	5	0	4
MA 101	Writing and the Humanities	3	0	3
EG 101	Intro to Engineering	2	3	3
10				

## Second Semester

MA 107	Calculus II	5	0	4
PH 107	Mechanics	4	0	3
EG 102	Intro to Eng. Design	2	3	3
10				

## SECOND YEAR

### First Semester

MA 108	Differential Equations & Numerical Methods	3	0	3
PH 108	Electr. Magnetism & Fluids	4	0	3
PH 118	Phys. Lab for PH 108	0	1.5	.5
SS 104	Contemp World Hist.	3	0	3
9.5				

### Second Semester

MA 109	Multidem Calculus	4	0	3
PH 109	Waves, Optics & Thermo	4	0	3
PH 119	Phys. Lab for PH 109	0	1.5	.5
HU 200	Writing & Human. II	3	0	3
9.5				

## THIRD YEAR

### First Semester

ME 111	Eng. Mechanics I	3	0	3
CM 101	General Chemistry I	3	0	2.5
CM 111	General Chem. Lab I	0	1.5	.5
CS 200	Programming Method.	4	0	3
9				

### Second Semester

CE 112	Mechanics of Mat.	3	0	3
CM 102	Gen. Chemistry II	3	0	2.5
CM 112	Gen. Chem. Lab II	0	1.5	.5
HU 110	Prof. Report Writ.	3	0	3
9				

## FOURTH YEAR

### First Semester

CE 153	Meas. in Civil Eng.	1.5	1.5	2
CE 322	Anal. of Structures I	3	0	3
ME 201	Thermodynamics	3	0	3
8				

## Second Semester

CE 223	Fluid Mechanics	2.5	1.5	3
EE 370	Princ. of Elect. Eng.	3	0	3
6				

## FIFTH YEAR\*+

### First Semester

CE 307	Construction Mat.	2	3	3
CE 340	Water Resources & Hydraulic Eng.	3	0	3
6				

### Second Semester

CE 232	Soil Mechanics	2	3	3
HU/SS	Hum/Soc Sci Elective	3	0	3
6				

## SIXTH YEAR\*\*

### First Semester

MA 222	Intro to Probab. & Statistics	3	0	3
CE 215	Computer Techniques in Civil Engineering	1.5	1.5	2
HU/SS	Hum/Soc Sci Elective	3	0	3
8				

### Second Semester

CE 323	Anal. of Struct. II	3	0	3
CE 331	Steel Structures	2	3	3
HU/SS	Hum/Soc Sci Elective	3	0	3
9				

## SEVENTH YEAR\*+

### First Semester

CE 341	Environmental Eng. I	2	3	3
CE 351	Highway & Trans Eng II	3	3	3
HU/SS	Hum/Soc Sci Elective	3	0	3
9				

### Second Semester

CE 342	Environmental Eng. II	2	3	3
CE 352	Traffic Engineering	3	0	3
HU/SS	Hum/Soc Sci Elective	3	0	3
9				

## EIGHTH YEAR\*\*

### First Semester

CE 252	Reinf. Concrete Structures	3	0	3
CE 317	Foundations	2	3	3
	Technical Elective	3	0	3
9				

### Second Semester

CE 332	Design of Struct Sys.	2	3	3
CE 335	Proj. Mgmt for Const.	3	0	3
	Technical Elective	3	0	3
9				

\*+ Offered in alternate odd years, i.e., 1993-1994, 1995-1996 (the fifth and sixth years are interchangeable)

\*\* Offered in alternate even years, i.e., 1994-1995, 1996-1997 (the seventh and eighth years are interchangeable)

**GRADUATE PROGRAMS**

The Department of Civil and Environmental Engineering offers graduate degree programs in three major discipline areas:

- Civil Engineering
- Environmental Engineering and Environmental Health Science
- Transportation

These programs lead to the following degrees:

**Master of Science**

- Civil Engineering
- Environmental Engineering
- Environmental Health Science
- Transportation Planning & Engineering
- Transportation Management

**Engineer's Degree**

- Civil Engineering

**Doctor of Philosophy**

- Civil Engineering
- Environmental Health Science
- Civil Engineering (Subtitle: Transportation Planning and Engineering)

Information on graduate degree programs in Civil Engineering is presented below. The programs in Environmental Engineering and Environmental Health Science and in Transportation are described in separate sections of this catalog.

Civil engineering graduate programs are designed to address the critical needs of industry and government for specialized engineering education, focusing on current design practices, technological developments, project management techniques, and new engineering applications. They serve both regular full-time students and professionals who elect to be part time students.

MS degree programs in Civil Engineering are practice oriented with a strong emphasis on advanced design principles, experimental techniques, and state of the art construction technologies. However, for specific discipline areas, engineering economics, operational system management and relevant basic sciences are major components of the academic program.

Requirements for the master's degree include prescribed courses and approved elective courses. A project must be completed; a thesis of 6 units may be substituted for the project and one elective course. A minimum of 36 units is required for the degree.

Engineer degrees are oriented toward civil engineers who wish to study advanced engineering techniques, construction technologies, environmental projects, engineering management, or material sciences beyond the master's degree. A minimum of 24 units of approved graduate courses and a minimum of 12 units of design project are required.

The Ph.D. degree requires advanced study beyond the master's degree level and high level original research work. A thesis must be written and defended.

Computer literacy is a requirement for all areas of specialization. In some cases, an undergraduate or graduate course may be included in the program of study to overcome deficiencies.

Students interested in graduate programs in civil engineering are advised to refer to the Graduate Student Manual (available from the office of the Department of Civil and Environmental Engineering) for information on degree requirements and the latest revisions of curricula and courses.

**REQUIREMENTS FOR THE MASTER'S DEGREE**

Students pursuing the M.S. in civil engineering generally have undergraduate preparation in civil engineering. Students pursuing this degree who have undergraduate or graduate degrees in other fields may qualify for this program by completing additional undergraduate engineering courses. When a student pursues both the B.S. and M.S. degrees simultaneously at Polytechnic, the bachelor's degree requirements must be completed first.

Courses in some areas of specialization are not offered on a regular basis. Students should consult with the department advisers to determine the expected scheduling of such courses.

**M.S. PROGRAMS IN CIVIL ENGINEERING**

M.S. programs are offered with majors in the following specialty areas: structural materials and engineering, environmental and water resources, geotechnical and geo-environmental engineering, and construction management and highway engineering.

**Departmental Requirements**

The following courses are required of all students:

No.	Course	Units
CE 780	<i>Analysis of Uncertainty In Civil Engineering</i>	3
CE 996	<i>Project for the Degree of Master of Science</i>	3
		<b>(6 Units)</b>

**Required Major Courses**

Five core courses in one of the majors must be completed: structural materials and engineering, environmental and water resources, geotechnical and geo-environmental engineering, or construction management and highway engineering.

**(15 units)**

**Electives**

Five courses approved by the student's adviser must be completed.

**(15 units)**

**Total** **36 units**

**CORE COURSES**

**Structural Materials and Engineering:**

CE 601	<i>Theory of Structural Analysis and Design</i>	3
CE 609	<i>Computer Methods of Structural Analysis</i>	3
CE 614	<i>Steel Structures</i>	3
CE 625	<i>Structural Dynamics</i>	3
CE 641	<i>Reinforced Concrete Structures</i>	3
		<b>15</b>

# CIVIL ENGINEERING

## Environmental and Water Resources:

CE 722	Hydrology	3
CE 723	Groundwater Hydrology & Pollution	3
CE 737	Environmental Chemistry & Microbiology I	3
CE 742	Water & Wastewater Treatment I	3
CE 747	Analysis of Stream & Estuary Pollution	$\frac{3}{15}$

## Construction Management and Highway Engineering:

CE 796	Fund. of Pavement Design	3
CE 814	Advanced Pavement Technology	3
CE 825	Project Management for Construction	3
CE 827	Contracts & Specifications	3
CE 829	Construction Operations Anal.	$\frac{3}{15}$

## Geotechnical and Geo-Environmental Engineering:

CE 849	Environmental Geotechnology	3
CE 851	Stress-Strain Behavior and Seepage	3
CE 861	Shear Strength of Soils & Limit Analysis	3
CE 863	Experimental Soil Mechanics	3
CE 871	Foundation Engineering	$\frac{3}{15}$

## 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 in civil engineering. The program follows:

No.	Required Subjects	Units
CE 998	Project for the Degree of Engineer An approved elective in applied mathematics, or	12

operations research	3
Nine units of courses in areas of specialization selected with the consent of the adviser	$\frac{9}{24}$
Required units	24
Minimum elective units	$\frac{12}{36}$
Minimum total units	36

## REQUIREMENTS FOR THE DOCTOR'S DEGREE

Students with exceptional scholastic ability may pursue a doctorate in civil engineering. Majors are offered in structural materials and engineering, environmental engineering, water resources and hydraulic engineering, construction project management, highway materials and engineering, and geotechnical and geo-environmental engineering. The doctorate in civil engineering is also offered with a major in transportation planning and engineering; information on this program is described in the section of this catalog on Transportation.

An applicant for a doctorate in civil engineering must hold a master's degree in civil engineering. Applicants with degrees in other fields may be admitted with deficiencies as evaluated by a departmental graduate adviser and upon approval of the department head.

All doctoral students must complete a minimum of 90 units of work beyond the bachelor's degree. Minimum requirements of formal coursework (not including guided readings, seminars, projects, or theses) are 48 units beyond the bachelor's degree or 24 units beyond the master's degree. Generally, at least 12 units of formal coursework must be completed at Polytechnic. Ph.D. students must select a major field and two minor fields in consultation with the advisers. Each minor consists of 9 to 15 units of approved courses.

To qualify as Ph.D. candidates, students must pass a written and oral qualifying examination on the major and one minor. The oral examination may be waived in exceptional cases by the department head upon the recommendation of the examining committee. Generally, students take the qualifying examination within their first year of full time course work beyond the M.S. degree. Students are allowed a maximum of 3 attempts to pass the qualifying exam.

Students must submit and orally defend dissertation proposals within one semester after the initial registration for dissertation units or before going beyond 9 dissertation units. Registration for a total of 30 units of dissertation research is required. Registration should be continuous until the dissertation has been completed and accepted.

## UNDERGRADUATE COURSES

### CE 153 Measurements in Civil Engineering 1/1:1/1:2

Overview of surveying and mapping. Fundamental techniques in distance measuring, leveling, angle and direction measurements. Cross section leveling. Errors and corrections. Area and volume calculations. Traverse and route surveys. Curve location and layout. Topographic and mapping surveys. Photogrammetry, GIS and remote sensing. Applications of surveying: leveling and road layout; land, boundary and control surveys. Reports and other presentations based on laboratory experimentation.

### 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: ME 111.*

### CE 215 Computer Techniques in Civil Engineering 1/1:1/1:2

Use of a high level computer language, numerical methods, and computer techniques to solve engineering problems: emphasis on modeling civil engineering systems for computer solution, selection of appropriate numerical technique, development and use of civil engineering programs, and interpretation of computer results. *Prerequisite: CS 200, Corequisite: MA 108.*

### CE 223 Fluid Mechanics 2/1:1/1:3

Fluid properties. Hydrostatics. Continuity, energy and momentum equations. Laminar and turbulent flow.

Similitude and dimensional analysis. Incompressible flow in closed pipes. Laboratory work parallels and supplements lectures. *Prerequisite: ME 111*

**CE 232 Soil Mechanics** 2:3:3

Geological soil-forming processes and physical and mechanical properties of soils. Plasticity, capillarity, permeability, stress distribution in soil masses, consolidation theory, settlement of structures. Laboratory studies of physical and mechanical properties of soils. *Prerequisites: CE 223 and CE 202.*

**CE 252 Reinforced Concrete Structures** 3:0:3

Fundamentals of analysis and design of reinforced concrete beams, columns, slabs. *Prerequisite: CE 322.*

**CE 307 Construction Materials** 2:3:3

Material properties and behavior. Environmental impact and concerns. Structure, physical and mechanical properties of construction materials such as: timber, aggregates, asphalt, concrete, metals and alloys, plastics, masonry and mortar. Relationship between microstructure and behavior. Asphalt and concrete mixture design, performance and deterioration. Plastics and geosynthetics. Reclaimed materials and recycling of waste products in civil engineering applications. Materials related to environmental hazards. Experimental investigation of mechanical and physical properties of selected construction materials.

**CE 317 Foundations** 2:3:3

Site explorations and soil sampling; planning boring programs and interpretation of boring logs. Bearing capacities and 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 Analysis of Structures I** 3:0:3

Analysis of statically determinate beams, frames and trusses. Deflection calcula-

tions using energy methods. Analysis of indeterminate structures using superposition. Determinate and indeterminate influence lines. Slope deflection. *Prerequisite: CE 202.*

**CE 323 Analysis of Structures II** 3:0:3

Analysis of statically indeterminate linear frames by moment distribution. Matrix analysis of structures using force and stiffness methods. Computer applications. *Prerequisite: CE 322.*

**CE 331 Steel Structures** 2:3:3

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

Comprehensive design integrating site planning, environmental, geotechnical and structural engineering, specifications, estimating construction and scheduling activities including a project report. Lectures, workshop sessions and final project presentation simulating multidisciplinary design office experience. *Prerequisites: CE 323, CE 252, CE 317 and CE 331.*

**CE 335 Project Management for Construction** 3:0:3

The participants, processes and techniques required to maintain the life cycle of a construction project. Planning of construction operations, including cost estimating and economic evaluation of alternatives. Analysis of the construction bid process, contracting, and related issues on ethics in project engineering. Productivity, safety and quality on the constructed project. Time scheduling of the project, including CPM and PERT. Trends in computer analysis of project information. *Prerequisite: Senior Status.*

**CE 336 Timber and Masonry Structures** 3:0:3

Properties and classification of structural lumber. Design of timber connectors.

Design and erection of residential and industrial timber buildings. Beams, frames, columns and trusses of sawn lumber and glued-laminated construction. Manufacture and properties of concrete masonry units. Properties of mortar and grout. Design and construction of load-bearing reinforced and unreinforced masonry structural elements. *Prerequisite: CE 252, CE 322, CE 331.*

**CE 340 Water Resources and Hydraulic Engineering** 3:0:3

Fluid Measurements. Hydrologic techniques. Surface water and ground water supplies. Open channel flow. Water transmission and distribution. Wastewater and storm water drainage. Development of water resources projects. *Prerequisite: CE 223.*

**CE 341 Environmental Engineering I** 2:3:3

Water and wastewater quantities. Water quality. Water and wastewater treatment, stream assimilation, public health and environmental problems. Laboratory analyses of water and wastewater samples, treatment process tests. *Prerequisites: CE 223 and CE 340.*

**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 340 and CE 341.*

**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 223.*

**CE 351 Highway and Transportation Engineering** 2:3:3

Fundamentals of highway and transportation engineering including land, urban, air and water transportation. Geometric design, capacity intersection design, drainage, economic analysis and finance, rigid and flexible pavements,

## CIVIL ENGINEERING

velocity profile and performance, evaluation, future developments. *Prerequisite: CE 153.*

### **CE 352 Traffic Engineering** 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.*

### **CE 353 CAD in Civil Engineering** 2:3:3

Thorough exposure to architectural CAD in civil engineering design. Fundamentals of CAD, its uses, and types of CAD equipment and software. Principles of transformations, geometric modelling and drafting. Interactive computer graphics, 3-D modelling, and effect of color. Application of CAD to engineering analysis. Incorporation of CAD in project data management. Laboratory assignments to reflect coursework. *Prerequisites: EG 102, CS 200 and Senior status.*

### **CE 391-392 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 register for thesis until completed. *Prerequisite: Senior status.*

### **CE 396 Civil or Environmental Engineering Internship** 2:0:2

Supervised, creative civil or environmental 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 visitations 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 or Environmental Engineering** 2 or 3 credits as arranged

Solution to civil or environmental 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

### **UNCLASSIFIED**

### **CE 598-599 Special Topics in Civil Engineering** 2/1:0:3

Specialized current topics of interest of an interdisciplinary nature. Offered at irregular intervals. Advance announcements include course description and prerequisites.

### **CE 780 Analysis of Uncertainty in Civil Engineering** 2/1:0:3

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.

### **CE 781 Analysis of Public Works** 2/1:0:3

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. **Also listed under MG 830.**

### **CE 790 Fire Protection Engineering** 2/1:0:3

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** 2/1:0:3

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 215 or equivalent.*

**STRUCTURAL MATERIALS  
AND ENGINEERING**

*Prerequisites for all courses: MA 108,  
CE 323*

**CE 601 Theory of Structural  
Analysis and Design** 2½:0:3

Theories of structural analysis and its relationship to design. Classical structural mechanics, matrix procedures and numerical methods of solution. Analysis of statically indeterminate beams, frames, and trusses using force and displacement methods. Emphasis on elastic supports, movement of supports and temperature effects. *Prerequisite: CE 323.*

**CE 603-604 Special Topics in  
Structural Analysis I, II** 2½:0:3

Specialized current topics of interest offered at irregular intervals by advance announcement. Graduate advisers may approve repeated registration for different topics. *Prerequisite: Approval of Adviser*

**CE 605 Plate and Shell Structures** 2½:0:3

Analysis of plate and shell structures with particular emphasis on civil engineering applications of shells. Analysis of plates by finite differences. Membrane solution of shells of revolution, cylinders, elliptic and hyperbolic paraboloids. Asymptotic solution for symmetrically loaded shells of revolution. Folded plates. *Prerequisite: Approval of Adviser*

**CE 606 Bridge Engineering** 2½:0:3

Types of bridges. Geometric design of bridges. Construction materials. Construction techniques. Simplified bridge analysis. Special problems in the design of steel and reinforced concrete bridges. Bridge maintenance techniques. Bridge inspection policy. Bridge rehabilitation procedures. Bridge management systems. Effects of wind and earthquakes on long-span bridges. *Prerequisites: CE 252, 323, 331.*

**CE 609 Computer Methods of  
Structural Analysis** 2½:0:3

Basic concepts of matrix methods in structural analysis. The direct stiffness

method applied to trusses and frames. Force and displacement transformations. Complete solutions of structural problems by chain matrix operations. Assemblage of stiffness and flexibility matrices of an entire structure. Computer program development for structural analysis, with particular emphasis on the direct stiffness method. *Prerequisite: CE 601.*

**CE 611 Limit Analysis of  
Structures** 2½:0:3

Plastic analysis of shafts, beams and frames. Failure mechanisms and collapse loads. Upper- and lower-bound theorems. Cyclic loading and shakedown problems. Optimization, minimum weight design. Yield conditions and flow rules. Limit loads of plates. *Co/Prerequisite: CE 601.*

**CE 613 Stability of Structures** 2½:0:3

Stability concepts. Investigation of buckling of structural configurations composed of beams, plates, rings, and shells. Effects of initial geometric imperfections, load eccentricities, and inelastic behavior. Application of energy methods and numerical techniques. *Prerequisite: CE 601.*

**CE 614 Steel Structures** 2½:0:3

Compression members; elastic and inelastic buckling of columns and plates. Beams: laterally supported. Torsion of open and closed sections. Warping. Lateral torsional buckling of beams. Biaxial bending. Plate girders; stability of webs and flanges. Combined bending and axial load, instability analysis. Design of rigid and semirigid mechanisms of continuous beams and rigid frames. Elastic/plastic design criteria. *Prerequisite: CE 331 or equivalent.*

**CE 616 Finite Element Methods** 2½:0:3

Derivation of element stiffness matrices. Construction of general stiffness matrices in global coordinates. Application to problems in plane stress, plane strain, plates, and shells under various loads. Emphasis on computer applications. *Co/Prerequisite: CE 609.*

**CE 617 Introduction to Modern  
Concepts of Structural Safety** 2½:0:3

Introduction to modern concepts of structural safety limit states designs based on reliability analysis. Design code formats. Risk analysis. Semi-probabilistic Safety index analysis. Code optimization. Single load stochastic models; extreme value and holding time analysis. Combined load analysis; scalars, vectors. Basic system reliability. Conditional analysis, modeling errors and engineering judgment. *Prerequisite: CE 780.*

**CE 621 Advanced Mechanics of  
Materials** 2½:0:3

Unsymmetrical bending of elastic bars, shear center for members of thin-walled open cross section, curved beams, beams on elastic foundations, membrane and bending stresses in shells. *Prerequisite: Approval of Adviser*

**CE 625 Structural Dynamics** 2½:0:3

Dynamic response of single degree of freedom systems. Theory of vibration of finite degree of freedom systems. Influence coefficient method. Analytical and numerical solution of dynamic response problems. Nonlinear analysis of single degree of freedom system. Emphasis on computer analysis of large complex systems. *Prerequisite: CE 609. Also listed under ME 741.*

**CE 626 Applied Structural  
Dynamics**

Review of classical structural dynamics. Introduction to linear random vibrations. Power spectra, auto and cross-correlation functions. Wind loads, galloping, flutter, buffeting, vortex shedding. Response of civil engineering structures to wind effects. Seismic loads. Linear and nonlinear response spectra. Ductility. Simplified seismic analysis and design of structures. *Prerequisite: CE 625.*

**CE 632 Piping System Analysis  
and Design** 2½:0:3

Use of displacement energy, complementary energy and thermoplastic reciprocal theorem in solution of problems of

## CIVIL ENGINEERING

plane bending of rings, frames and piping; three-dimensional analysis of piping systems; computational methods of analysis using concepts of elastic center; bending of bimaterials and layered elements. *Prerequisite: CE 601 or equivalent.*

### **CE 641 Reinforced Concrete Structures** 2½:0:3

Ultimate strength design of reinforced concrete members. Biaxial bending and slender effects of reinforced concrete columns. Limit design, redistribution of moments. Design of slabs using yield line theory. Deep beams and shear walls. Analysis and design for torsion. *Prerequisite: CE 252 and Co/Prerequisite: CE 601.*

### **CE 643 Prestressed Concrete** 2½:0:3

Principles and materials for prestressed concrete. Flexural strength of prestressed members. Design of pretensioned and post-tensioned beams, columns, and slabs. Effect of short-term and long-term deformations. Analysis and design of prestressed concrete structures. *Prerequisite: CE 641.*

### **CE 645 Fracture Mechanics-Modelling and Design** 2½:0:3

Fracture mechanics combines solid mechanics and materials science in order to study and design against the fracture of engineering materials in service. Applications include the study of shear banding in soils, pressure vessel and pipeline failures, cracks in concrete and steel structures, fracture of rails, fatigue failure of machine components, and the design of advanced fracture resistant materials. This course will emphasize the modelling of fracture processes and the use of fracture mechanics in engineering design. *Prerequisite: Approval of Adviser. Also listed under ME 735, MT 645*

## **WATER RESOURCES ENGINEERING**

*Prerequisite for all courses: MA 108, CE 223*

### **CE 712 Water Resources Projects** 2½:0:3

Feasibility-level planning and design studies for water resources projects, including water conveyance works; concrete dams and associated waterways; pumping stations; hydroelectric, irrigation, navigation, and flood mitigation projects. Subjects considered include layouts, dimensions and capacity of facilities, hydraulic and structural forces, and stability analysis. *Co/Prerequisite: CE 340 or CE 715, or approval of Adviser*

### **CE 715 Open Channel Hydraulics** 2½:0:3

Theory and computations for uniform flow, gradually varied flow, rapidly varied flow, unsteady flow in prismatic and non-prismatic channels.

### **CE 716 Applied Hydraulics** 2½:0:3

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 340 or CE 715.*

### **CE 722 Hydrology** 2½:0:3

Hydrologic cycle. Meteorological considerations. Analyses of precipitation, runoff, unit hydrographs, flood routing and reservoir storage. Principles of groundwater hydrology. Introduction to frequency analysis of floods and droughts. *Prerequisite: Approval of Adviser*

### **CE 723 Groundwater Hydrology and Pollution** 2½:0:3

Characteristics of confined and unconfined flow of water through porous media; groundwater and well hydraulics; quality of ground water; environmental influences; groundwater pollution; management aspects of groundwater; and groundwater modelling. *Prerequisite: CE 340 or Approval of Adviser*

### **CE 724 Advanced Groundwater Hydrology and Pollution** 2½:0:3

Mass and heat transport in porous media. Unsaturated flow and transport. Numerical solutions of governing equa-

tions. Stochastic analysis. Groundwater quality monitoring and simulation. Dispersive mixing, decay, adsorption, retardation. Soil microbiology. Soil and groundwater monitoring. Control of subsurface pollution and treatment technologies. Case studies. *Prerequisite CE 723 or equivalent.*

### **CE 725 Water Resources Mathematical Modeling** 2½:0:3

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: Course in computer programming and Co-Prerequisite: CE 715.*

### **CE 726 Computer Applications in Water Resources** 2½:0:3

Applications of commercial software in water resources planning and design. Class meets in a computer classroom and hands-on experience is offered. Examples include analysis of flood hydrographs, open channel flow, river hydraulics, pipe networks, watershed hydrology, storm water management, and groundwater flow and transport. *Prerequisite: CE 340.*

### **CE 727 Urban Hydrology** 2½:0:3

Urban climate. Rainfall: IDF methods, spatial variability, design hyetographs. Hydrologic routing. Hydraulic routing. Urban water quality. Probabilistic modeling. Use of computer models. *Prerequisite: CE 722 or equivalent.*

### **CE 728 Optimization Methods in Water Resources** 2½:0:3

Advanced theory of mathematical programming and optimal control with applications in planning and operation of water resource systems. *Prerequisite: CE 722 or equivalent.*

**CE 735-736 Special Topics in Water Resources and Hydraulic Engineering I, II** 2½:0:3

Topics in water resources and hydraulic engineering such as hydroeconomic models; finite difference and finite element models; synthetic hydrology; conjunctive use of surface water and ground water; desalination and recycled water; thermohydrologic and hydrometeorological problems; flushing of estuaries; hydrodynamics of oil pollution, sludge dumping, and sediment movement; environmental design of hydraulic structures, problems of macro projects. *Prerequisite: Approval of Adviser*

**ENVIRONMENTAL ENGINEERING**

**CE 737 Environmental Chemistry and Microbiology I** 1:2:3

Introduction to the chemistry and microbiology of polluted and natural waters, including applications of principles developed.

**CE 739 Environmental Chemistry and Microbiology II** 1:2:3

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment.

**CE 742 Water and Wastewater Treatment I** 2½:0:3

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 737.*

**CE 743 Water and Wastewater Treatment II** 2½:0:3

Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. *Co-Prerequisite: CE 739.*

**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** 2½:0:3

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** 2½:0:3

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** 2½:0:3

Theory, methodology and instrumentation associated with environmental health. Topics include epidemiology, food vectors, radiation, pest control, heating, ventilation, noise, illumination, hazards of home and community environment, other subjects which affect public health.

**CE 752 Air Pollution** 2½:0:3

Causes and effects of air pollution. Methods of sampling. Interpretation of data. Meteorological aspects. Methods of air pollution control.

**CE 753 Hazardous/Toxic Waste Management** 2½:0:3

Methods in the management of hazardous/toxic waste sites. Topics covered

include health and safety, legal aspects, contamination of the environment, treatment processes, toxicology and risk assessment.

**CE 758 Air Pollution Engineering Control** 2½:0:3

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: Approval of Adviser. Also listed under CH 752.*

**CE 767 Environmental Impact Evaluation** 2½:0:3

An examination of legal and technical requirements in the preparation of environmental impact evaluations. 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 are used.

**CE 770 Solid Waste Management** 2½:0:3

Engineering aspects of solid waste collection, transport and disposal, including incineration, sanitary landfill, composting, recovery and reutilization, economic evaluation of factors affecting selection of disposal methods.

**CE 771-772 Special Topics in Environmental Engineering I, II** 2½:0:3

Current topics including nitrification in natural and treated waters, hazardous and toxic wastes, organic removal from water supplies, water reuse, specialized aspects of biological wastewater treatment, environmental health, solids disposal, and modeling natural waters and treatment systems. *Prerequisite: Approval of Adviser*

## CIVIL ENGINEERING

### GEOTECHNICAL AND GEO-ENVIRONMENTAL ENGINEERING

*Prerequisites for all courses: MA 108,  
CE 232, CE 317*

#### **CE 849 Environmental Geotechnology** 2½:0:3

Chemical phase transfer. Acids and bases in soils. Chemical reactions in soils. Identification, clay mineralogy. Hydraulic conductivity, diffusion and unsaturated flow. Well hydraulics. Contaminant transport. Flow potentials. Seepage barriers. Bioremediation. *Prerequisite: CE 223.*

#### **CE 850 Ground Improvement** 2½:0:3

Classification of available technologies. Performance criteria. Physical and chemical soil behavior; testing and design parameters. Reinforced soil retaining systems; metal reinforcement and geotextiles. Chemical, thermal and physical ground treatment. Densification by vibro/dynamic ground replacement. Soil nailing and ground anchors. Design methods. Case histories. Environmental applications; seepage barriers, remediation. New trends in ground improvement.

#### **CE 851 Stress-Strain Behavior and Seepage** 2½:0:3

Conjugate stress relationships in infinite slopes in granular and cohesive soils. Studies of classical works of Rankine, Coulomb, Kerisel 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 861 Shear Strength of Soils and Limit Analysis** 2½:0:3

Index properties of soils. 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. Strength of soils.

#### **CE 862 Physical and Chemical Soil Behavior** 2½:0:3

Strength of soils, laboratory tests, effective strength parameters, total and effective stress paths. Applications of soil strength in stability analysis of embankments. Critical state soil mechanics, constitutive relations for soils. *Prerequisite: CE 861.*

#### **CE 863 Experimental Soil Mechanics** 1:2:3

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** 2½:0:3

Soil sampling and exploration procedures. Analytical procedures for determining bearing capacity as a function of stability and settlements. Plate-loading test shallow footing design. Analysis and design of mat footings. Design of deep foundations; piles, piers and caissons.

#### **CE 881-882 Special Topics in Geotechnical Engineering & Pavement Technology I, II** 2½:0:3

Current topics of interest such as theoretical determination of pile capacities, sheet pile bulkheads and trench problems, stress on tunnels, theoretical approaches to soil stability and settlement, soil reinforcement applications, pavement performance and rehabilitation, pavement management systems, pavement improvement techniques, pavement performance evaluation, recycling technologies, pavement on sensitive soils. *Prerequisite: CE 851, CE 861, CE 871 or CE 797 depending on subject area.*

#### **CE 892 Soil Dynamics and Earthquake Engineering** 2½:0:3

Single- and multi-degrees of freedom systems. Wave propagation in homogeneous and layered half-spaces. Behavior of dynamically loaded soils. Basic concepts of seismology; earthquake distribution, type, magnitude, intensity, energy and seismic regionalization. Response spectrum. Effect of earthquakes on soil and response of structures to earthquakes as influenced by soil formation. Design of dynamically loaded foundations and earth structures. The liquefaction problem. *Prerequisite: CE 861.*

#### **CE 893 Rock Mechanics and Underground Structures** 2½:0:3

Intact rock and rock mass description and engineering properties; static ground-structure interaction, stability and wedge analysis, underground structures in rock and soft soil.

#### **CE 895 Performance Monitoring and In-Situ Testing** 2½:0:3

Introduction to soil and rock behavior. The "observational" method. Geotechnical instrumentation: types, applications, uncertainty. Planning a monitoring program. Case histories. The need for in-situ parameters. Penetration testing. Pressuremeter. Dilatometer. Stepped blade. Wave based methods (mechanical and electromagnetic). Case histories and controlled laboratory studies. New trends in monitoring and in-situ testing.

### CONSTRUCTION MANAGEMENT

#### **CE 798-799 Special Topics in Infrastructure Systems and Construction** 2½:0:3

Current topics of interest such as 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

**CE 820 Project Management** 2½:0:3

Specific management concepts and techniques related to management of special projects in research and development, construction, engineering, and data processing. Functional and administrative structures, coordination of activities, manpower planning, feasibility analyses, negotiations and contracts. **Also listed under MG 820.**

**CE 825 Project Management for Construction** 2½:0:3

Topics specific to the development and coordination of large projects, including; organizational structures, management functions, pricing and estimating project costs, bidding and contracting, risk allocation, scheduling, time and cost control, labor relations, quality management, as well as project life cycle activities. **Also listed under MG 825.**

**CE 826 Construction Cost Estimating** 2½:0:3

Estimates, and costs from the viewpoint of contractor or construction engineer, details of estimating, emphasis on labor, material, equipment, overhead costs. **Also listed under MG 826.**

**CE 827 Contracts and Specifications** 2½:0:3

Principles of contract law as applied to the construction industry; legal problems in preparing and administering construction contracts. **Also listed under MG 827**

**CE 828 Project Planning and Control** 2½:0:3

Network planning techniques for project management and resource allocation. Emphasis on PERT, LOB, CPM and probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Network development, computer adaptation, progress reports and project monitoring. *Prerequisite: knowledge of computer programming.* **Also listed under MG 810 and IE 620.**

**CE 829 Construction Operations Analysis** 2½:0:3

Evaluation and model development of productivity, safety, quality, and materials handling in construction operations. Principal methods for analysis and pre-planning of work activities, including the use of work sampling, questionnaires, and surveys. The implementation of video/timelapse photography in field studies, and the incorporation of crew balances, flow diagrams, process charts, and five-minute ratings for task measurements. The introduction of task analysis, including queuing theory, to the modeling and analysis of construction operations. Introduction to construction simulation. Field implementation and projects. *Prerequisite: degree in civil engineering, or approval of Adviser*

**CE 830 Information Systems in Project Management** 2½:0:3

Development of a strong understanding of contemporary tools for managing the vast array of information in the project life cycle. Information handling is reviewed both from the perspective of knowledge acquisition and knowledge representation. Information analysis as qualitative and quantitative. Interpretation of knowledge as deterministic versus stochastic. Introduction to decision making under risk. The implementation of spreadsheets, databases and expert systems as information systems communication tools for project information handling. A review of technologies such as CAD databases, geographic information systems, decision support systems and videogrammetry as tools for project automation. *Prerequisite: Degree in civil engineering or approval of Adviser*

**CE 831 Engineering for Construction I: Methods and Technologies** 2½:0:3

Planning, design and equipment for new construction and for infrastructure rehabilitation. Engineering fundamentals of earth moving, soil stabilization, and compaction. Methods for tunneling through rock and earth, as well as rock blasting. Foundation grouting, piles and pile driving equipment. Dewatering systems and pumping equipment. Factors affecting the selection of construction equipment. Review of conventional

construction equipment and trends in robotics. *Prerequisite: Degree in civil engineering, or approval of Adviser*

**CE 832 Engineering for Construction II: Design** 2½:0:3

In-depth analysis of design methods for construction operations. Earth pressure analysis and structural analysis. Design for sheet pile walls, cofferdams, underpinning systems, tieback systems, and pipejacking systems. Details of a dewatering system design. Special studies in constructability and value engineering. *Prerequisite: CE 831, or permission of the instructor.*

**HIGHWAY ENGINEERING**

*Prerequisites for all courses: MA 108.*

**CE 796 Fundamentals of Pavement Design** 2½:0:3

Pavement types, design factors, traffic load analysis, pavement materials, stresses in flexible and rigid pavements, economic factors, pavement strategies, and design of flexible and rigid pavements. *Prerequisite: CE 351. Also listed under TR 722.*

**CE 797 Flexible and Rigid Pavements** 2½:0:3

Advanced course in design and evaluation of flexible and rigid pavements for highway and airports: system approach, stochastic process, pavement condition and performance, advanced traffic load analysis, subgrade investigation, properties of subbase, base, asphaltic, and concrete courses, climatic and environmental effects, design strategies, design of highways and airport pavements and pavement evaluation. *Prerequisite: CE 796. Also listed under TR 723.*

**CE 813 Pavement Materials Laboratory** 1:3:3

Practical course on testing of pavement materials: physical and indicative tests, soil classifications, CBR test, tests on asphalts, Marshall test, Hveem tests, fatigue testing, application of results in a design problem. *Prerequisite: CE 796. Also listed under TR 724.*

## CIVIL ENGINEERING

### **CE 814 Advanced Pavement Technologies** 2½:0:3

Advanced course on evolution and innovative recent paving technologies: AASHTO road test, pavement management system, concrete block pavements, pavement recycling, geotextiles in pavements, pavement rehabilitations, bituminous materials, modern materials. *Prerequisites:* CE 797, CE 813. **Also listed under TR 725.**

### **CE 881-882 Special Topics in Geotechnical Engineering & Pavement Technology I, II** 2½:0:3

Current topics of interest such as theoretical determination of pile capacities, sheet pile bulkheads and trench problems, stress on tunnels, theoretical approaches to soil stability and settlement, soil reinforcement applications, pavement performance and rehabilitation, pavement management systems, pavement improvement techniques, pavement performance evaluation, recycling technologies, pavement on sensitive soils. *Prerequisite:* CE 851, CE 861, CE 871 or CE 797 depending on subject area.

## **TRANSPORTATION**

### **CE 804 Travel Demand Forecasting** 2½:0:3

Theory and application of travel forecasting methods to predict the amount and nature of travel in transportation systems. **Also listed under TR 601.**

### **CE 805 Traffic Engineering I** 1:3:3

First course in a two-semester sequence covering the basic aspects of traffic engineering. Driver, roadway, vehicle, and traffic stream characteristics, and their influence on operations, controls and design. Traffic studies and data analysis; volume, speed, delay, density, accidents, etc. Concepts of traffic capacity and level of service analysis. Capacity and level of service analysis of limited access facilities: freeways, freeway components, two-lane rural highways, multi-lane highways. Laboratories emphasize the use of spreadsheets in data analysis and the use of computer packages for capacity and level of service analysis. **Also listed under TR 701.**

### **CE 807 Traffic Engineering II** 1:3:3

Second course in a two-semester sequence covering the basics of traffic engineering. Traffic control, operations, and management. Characteristics of signs, signals, and markings. The "Manual on Uniform Traffic Control Devices" and its use. Intersection control. Signal systems and coordination. Pretimed and actuated control. Design of street hardware. Traffic flow regulations and their implantation. Intersection and arterial analysis. *Prerequisite:* CE 805 or *Instructor's Permission.* **Also listed under TR 702.**

### **CE 808 Computer Applications for Transportation Planning** 2½:0:3

This course covers the practical use of computers for urban transportation planning with a major focus on the traditional transportation planning process (Trip Generation, Trip Distribution, Modal Split, Trip Assignment). The emphasis will be on the use of the TRANPLAN package a comprehensive transportation planning software for Highway and Public Transit Systems. Other areas of application will include Spreadsheets (Quattro Pro), SPSS and MAPINFO for data analysis. **Also listed under TR 606.** *Pre-requisite/Co-requisite:* CE 804

### **CE 812 Transportation Economics and Finance** 2½:0:3

Basic principles of present worth, single payment and uniform series, sinking funds, annualized costs. Differences in the public and private sectors of transportation: profit, depreciation, return of capital. Benefit-cost analysis. Rate of return. Bond issues. Formulation and use of unit costs in highways, transit, and other modes. History of financing of road systems, transit, and trucking. Privatization. Balance sheets, financial control, cash flow. Preparing a private venture business plan. **Also listed under TR 750**

### **CE 821 Design of Traffic Facilities** 2½:0:3

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 833 Introduction to Transportation Analysis** 2½:0:3½

Introduction to the analysis of data in transportation problems. Basic statistics is covered: means, variances, histograms, applications of normal, t, and chi square distributions, statistical tests, and sampling procedures; applications to transportation data collection, such as spot speed studies, Travel time and delay studies, and observance studies. Basic concepts in probability are introduced: probability of events, random variables, with applications to transportation decision-making problems. Discussion of other types of traffic studies, including parking studies, O-D studies, accident studies. **Also listed under TR 600.**

### **CE 834 Urban Transportation Planning and Congestion Management** 2½:0:3

This course covers the theory and practice of Urban Transportation Planning with a major focus on the methods and techniques for alleviating traffic congestion, through transportation system management and travel demand management. Areas of application will include travel corridors, major activity centers, and residential neighborhoods. This is a "hands on," "how-to" course. **Also listed under TR 607.** *Prerequisite:* CE 804

### **CE 835 Computer Applications and Analytic Techniques in Traffic and Transportation** 2½:0:3

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 702 or CE 807. **Also listed under TR 703.**

**CE 836 Transportation Workshop**  
0:5:3

Comprehensive projects designed to assure student's understanding of basic principles and their applications, drawing 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. *Prerequisite: TR 701 or CE 805. Corequisite: TR 702 or CE 807. Also listed under TR 629.*

**CE 837 Public Transportation**  
2½:0:3

Needs for public transportation in urban areas. Characteristics of public transportation services: commuter rail, rail transit, light rail transit, express and local buses, commuter paratransit modes, taxi and other paratransit services. Planning and operations of transit routes and systems. Transit service performance measures. Functional design of transit stations, park and ride facilities and transit rights-of-way. **Also listed under TR 660.**

**CE 838 Design of Rail Facilities**  
2½:0:3

Design of systems for moving passengers and freight on rails. Roadbeds, alignment, yard, stations, signal communications, and protection devices. Design of light-rail transit facilities. **Also listed under TR 665.**

**CE 839 Port Planning and Design**  
2½:0:3

Planning of marine terminal facilities for freight and passengers. Harbor and port capacity analysis. Functional design and control of ports. U.S. port terminal needs for containers and bulk freight. Port operations. **Also listed under TR 672.**

**CE 840 Planning and Design of Terminals**  
2½:0:3

Passenger and freight terminals with emphasis on system description of these facilities. Land, marine and air terminals. Methods for determining the levels

of service for pedestrian flows. TOFC and truck terminals are also covered. **Also listed under TR 670.**

**CE 841 Airport Planning and Design**  
2½:0:3

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.**

**CE 842 Intelligent Vehicle Highway Systems (IVHS)**  
2½:0:3

Intelligent Vehicle Highway Systems (IVHS) are a topic of much discussion, and a major thrust in Federal legislation. This course is designated to acquaint the student with the terminology, issues, and state of the art in IVHS activities and to cause discussions on the implications of IVHS activities. **Also listed under TR 704. Prerequisite: Approval of Adviser.**

**CE 843 Transportation Policy**  
2½:0:3

Analysis of the major policies, regulations, and controls established or imposed by government at all levels—federal, state, local— which currently impact on the transportation industry. (All modes considered). Case studies used extensively. **Also listed under TR 759.**

**CE 844 Management of Transit Maintenance and Operations**  
2½:0:3

Management of functional transit systems aspects, including design and monitoring of maintenance functions to provide viable operating fleets and right-of-way, and management of daily operations, including scheduling, run-cutting, dispatching, and street management. **Also listed under TR 760.**

**CE 845 - CE 846 Selected Topics in Transportation I, II**  
each 2½:0:3

Periodic presentation of topical materials of current interest. Topics presented are: site development and site impact; deci-

sion-making in transportation; computer packages in transportation; transportation systems safety. *Prerequisite: Approval of Adviser. Also listed under TR 860-861.*

**CE 847 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 hazards and hazardous conditions in every stage of the highway system activity cycle, including planning, engineering, design, operation, maintenance. **Also listed under TR 865.**

**GUIDED READINGS, SEMINARS, PROJECTS AND THESES**

**Note: Students should obtain a copy of the University's "Regulations on Format, Duplication and Publication of Reports, Theses and Dissertations" available from the Office of Research and Graduate Affairs.**

**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, except with department head's approval. *Prerequisite: Instructor's approval.*

**CE 903-904 Readings in Transportation I, II**  
each 2½:0:3

Special problems in transportation under the direct supervision of faculty members. *Prerequisite: academic adviser's approval. Also listed under TR 901-902.*

**CE 952 Seminar in Civil Engineering**  
nc

Lectures on recent developments in civil engineering given by representatives from industry, other research and educa-

## CIVIL ENGINEERING

tional institutions and Polytechnic graduate students and faculty.

### CE 954-955 Transportation Seminar I, II nc

Relevant topics in transportation by guest speakers. Presentations and discussions of on-going research by course participants and faculty. *Prerequisite: academic adviser's approval. Also listed under TR 951-952.*

### CE 957 Master's Project in Transportation Planning and Engineering each 3 units

An independent project leading to a comprehensive report demonstrating professional competence. Reports must be orally defended and be submitted in acceptable (unbound) written form. *Prerequisites: degree status and academic adviser's approval. Also listed under TR 962.*

### CE 958 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 reports must be orally defended and be submitted in acceptable (unbound) written form. *Prerequisites: degree status and academic adviser's approval. Also listed under TR 963.*

### CE 959 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 adviser's approval. Also listed under TR 966.*

### CE 996 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, and

following Department guidelines. Written report required. *Prerequisite: degree status and project adviser's approval.*

### CE 997 Thesis for the Degree of Master of Science 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 six (6) units required. Maximum of 12 units counted toward degree. Allowable registration per semester 3-12 units. *Prerequisite: degree status and thesis adviser's approval.*

### CE 998 Project for Degree of Engineer 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. Preferred registration per semester, 3-6 units; allowable registration 1-12 units with approval of department head. *Prerequisites: degree status and project adviser's approval.*

### CE 999 Dissertation for Degree of Doctor of Philosophy 6 units

Independent original investigation demonstrating creativity and scholarship worthy of publication in recognized engineering journals. Candidates must successfully defend their theses orally. Registration for minimum of 30 thesis units required prior to defense. Registration should be continuous. Preferred registration per semester, 6 units; allowable registration 1/2-18 units with approval of department head. *Prerequisites: degree status, completion of qualifying examinations and thesis adviser's approval.*

## FACULTY

**Ilan Juran**, Professor of Civil Engineering, Head of Civil and Environmental Engineering Department, B.S.C.E. Technion (Israel); Ph.D., D.Sc. University of Paris VI, Ecole National des Ponts et Chaussees. *Geotechnical engineering, soil improvement technologies, geosynthesis engineering, in-situ soil testing*

**George Bugliarello**, Professor of Civil Engineering; President, Polytechnic University  
Dott. Ing., University of Padua; M.S., University of Minnesota; Sc.D., Massachusetts Institute of Technology  
*Bioengineering; fluid mechanics*

**John C. Falocchio**, P.E., Professor of Transportation;  
B.C.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*

**Alvin S. Goodman**, P.E., Professor of Civil Engineering  
B.C.E. CCNY; M.S.C.E. Columbia University; Ph.D. New York University  
*Comprehensive water resources planning; water supply studies; hydrologic estimates; systems analysis of water resources; groundwater mathematical models; conjunctive use of surface and ground water*

**Herbert S. Levinson**, P.E., Research Professor of Transportation  
B.S.C.E. Illinois Institute of Technology; Certificate in Highway Traffic Engineering, Yale University.  
*Traffic operations, traffic engineering and capacity, highway engineering, transportation policy*

**William R. McShane**, P.E., Professor of Industrial and Systems Engineering; Director, Transportation Training and Research Center.  
B.F.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.*

**Robert T. Ratay**, P.E., Industry Professor of Civil Engineering and Coordinator of Department Programs in Farmingdale, B.S., M.S., Ph.D., University of Massachusetts  
*Earthquake and wind Engineering; structural stability; building science; structural design and construction practices*

**Roger P. Roess**, Professor of Transportation Engineering, Dean of Engineering, and Vice President for Academic Affairs  
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Traffic capacity and design; traffic engineering; public transportation; transportation economics*

**Feng-Bao Lin**, P.E. Associate Professor of Civil Engineering  
B.S.C.E., M.S. Struct. E. National Taiwan University; Ph.D. (Structural Mechanics), Northwestern University.  
*Constitutive modeling of engineering materials; fracture mechanics; nonlinear finite element analysis; design of steel and concrete structures.*

**Alan H. Molof**, Associate Professor of Environmental Engineering  
B.S.Ch.E. Bucknell University; M.S.E. (Ch.E.) M.S.E. (Sanitary Engineering) Ph.D. University of Michigan  
*Water and wastewater treatment processes; river and stream pollution; industrial waste treatment; hazardous/toxic waste management*

**Janet K. Yates**, Associate Professor of Civil Engineering  
B.S.C.E., M.S.C.E., University of Washington; Ph.D. Texas A & M University  
*Construction engineering and management, construction databases, decision support capabilities, constructibility and international finance, software systems for project management*

**Nabil Fares**, Assistant Professor of Civil Engineering  
B.S.C.E., M.S.C.E., Ph.D., Massachusetts Institute of Technology  
*Solid mechanics; fracture mechanics; boundary element methods; finite deformation theory; composite materials.*

**Dimitrios G. Goulias**, Assistant Professor of Civil Engineering  
M.S.C.E., Università Degli Studi Della Calabria, Italy; M.S.C.E., University of Michigan; Ph.D., University of Texas, Austin  
*Highway engineering; pavement design performance evaluation; pavement management; non-destructive testing*

**Dong-Soo Kim**, Assistant Professor of Civil Engineering  
B.S.C.E., M.S.C.E. Seoul National University  
Ph.D., University of Texas, Austin  
*Geotechnical engineering, soil dynamics, pavement materials testing and evaluation*

**Say Kee Ong**, P.E. Assistant Professor of Environmental Engineering  
B. Eng (M.E.), Univ. of Malaya, M.S. (Env. Eng) Vanderbilt University Ph.D. (Env. Eng.) Cornell University  
*Physical-chemical treatment processes for water quality control and hazardous waste management; aquatic chemistry; fate and transport of pollutants in the subsurface and surface water; wastewater treatment process modeling; toxicity reduction in wastewater*

**Sotiris A. Pagdadis**, Assistant Professor of Civil Engineering  
B.S.Eng. (A.S.E.), M.S. Eng.(E.M.), Ph.D. (CE) University of Texas, Austin  
*Construction engineering and management; artificial intelligence, database management, CAD; construction operations and simulation for constructibility review, infrastructure rehabilitation and quality management; new technologies for construction automation*

**Angelos L. Protopapas**, P.E. Assistant Professor of Civil Engineering  
Dipl. Eng. (C.E.), National Technical University of Athens (Greece); M.S. (Operations Research & Computer Sc), University of Athens (Greece); M.S.C.E., Ph.D., Massachusetts Institute of Technology  
*Surface and groundwater hydrology and pollution; water resources systems; urban hydrology; fluid mechanics; irrigation*

**Theva S. Thevanayagan**, P.E. Assistant Professor Civil Engineering  
B.S. Peradeniya University (Sri Lanka); M.S.C.E., Ph.D. Purdue University.  
*Geotechnical engineering; environmental geotechnology; numerical modelling of soils; physico-chemical behavior of soils; in-situ testing*

**C-Y John Yoon**, Assistant Professor of Civil Engineering  
B.S.C.E., M.S.C.E., Massachusetts Institute of Technology; Ph.D., University of California, Berkeley  
*Computer aided structural analysis and design; object oriented programming and data base designs for engineering systems; integration of engineering software systems; non-linear finite element analysis of large structures*

**Elena V. Prassas**, Instructor in Transportation Engineering  
B.A. State University of New York, Oneonta; M.S. Polytechnic Institute of New York  
*Traffic engineering; transit and economics; AI applications; software systems for transportation applications*

**Jose M. Ulerio**, EIT Instructor of Transportation Engineering; Special Assistant to the Dean of Engineering  
B.S., M.S., Polytechnic Institute of New York  
*Highway engineering; highway capacity; transportation assignment; transportation demand estimation; CAD and CAE applications*

### EMERITUS FACULTY

**Paul R. DeCiccio**, P.E. Professor Emeritus of Civil Engineering; Director of Fire Research B.C.E., M.C.E., Polytechnic Institute of Brooklyn  
*Urban Systems; Fire Safety*

**Albert H. Griswold**, P.E. Professor Emeritus of Civil Engineering B.S.C.E., University of Connecticut; M.S.C.E., Columbia University  
*Mechanics*

**Stephen T. Mikochik**, Professor Emeritus of Civil Engineering B.C.E. Manhattan College; M.S. Rutgers-The State University  
*Geotechnical Engineering*

**James E. Miller**, Professor Emeritus of Meteorology A.B., Central Methodist College; M.S., New York University  
*Meteorology and Oceanography*

**Henry F. Soehngen**, P.E., L.S. Professor Emeritus of Civil Engineering B.C.E., M.C.E., Polytechnic Institute of Brooklyn; M.S., International Training Center for Aerial Surveys, Delft (Netherlands)  
*Computer Science, Surveying and Photogrammetry*

**Robert C. Veit**, Professor Emeritus of Civil Engineering C.E., M.C.E., Polytechnic Institute of Brooklyn  
*Structures*

**Ping Chun Wang**, P.E. Professor Emeritus of Civil Engineering B.S.C.E., National Central University of China; M.S.C.E.; Ph.D., University of Illinois  
*Structures*

**Chilton A. Wright**, Professor Emeritus of Civil Engineering C.E., M.C.E., Ph.D., Cornell University  
*Hydraulic Engineering*

### ADJUNCT FACULTY

**Milton Alpern**, P.E. Adjunct Professor of Civil Engineering; B.C.E. Cooper Union; M.S. Structural Eng., Columbia University

**Raul R. Cardenas, Jr.**, Adjunct Professor of Environmental Engineering B.A., University of Texas; M.S., Ph.D., New York University

**Joseph C. Cataldo**, P.E. Adjunct Professor of Civil Engineering B.C.E., M.S.C.E., Ph.D., CCNY

**Philip A. Habib**, P.E. Adjunct Professor of Transportation Engineering B.E. City College of New York; M.S., Ph.D., Polytechnic Institute of Brooklyn

**Michael Horodniceanu**, P.E. Adjunct Professor of Transportation Engineering B.S. Technion Israel Institute of Technology; M.S. Columbia University; Ph.D. Polytechnic Institute of New York

**Mohammad Karamouz**, P.E. Adjunct Professor of Civil Engineering B.S.C.E., Pahlavi University (Iran); M.S.C.E., George Washington University  
Ph.D., Purdue University

**Walter Kraft**, P.E. Adjunct Professor of Transportation B.S.(CE) M.S.(CE) Newark College of Engineering, D.Engr. Sc. New Jersey Institute of Technology

**Rita Meyninger**, Adjunct Professor of Environmental Engineering B.S.C.E., Newark College of Engineering; M.S.C.E., New York University, Ph.D. Polytechnic University

**Anthony J. Rizzi**, P.E. Adjunct Professor of Civil Engineering B.S.E., M.S.C.E. CCNY

**John T. Tanacredi**, Adjunct Professor of Environmental Engineering B.S. Richmond College, M.S., Hunter College Ph.D., Polytechnic University

**Constantine Yapijakis**, Adjunct Professor of Civil Engineering M.C.E., National Technical University of Athens (Greece); M.S., New York University; Ph.D., Polytechnic Institute of New York

**Sidhartha Bagchi**, P.E. Adjunct Associate Professor of Civil Engineering B.A., Calcutta University; B.E.C.E., Calcutta University; M.E.C.E., Calcutta University; Ph.D., Polytechnic Institute of New York

**Alfred Berg**, P.E. Adjunct Associate Professor of Civil Engineering B.S.C.E., M.S.C.E., New Jersey Institute of Technology

**Ingo Fox**, P.E., Adjunct Associate Professor of Civil Engineering C.E. University of Chile; M.S. Eng. D.I.C. Imperial College, London University

**Bernard A. Grand**, P.E. Adjunct Associate Professor of Civil Engineering B.C.E., CCNY; M.S.C.E., Massachusetts Institute of Technology

**J.Jong Lou**, P.E. Adjunct Associate Professor of Civil Engineering B.S.C.E., National Taiwan University; M.S.C.E., Colorado State University; Ph.D., Northwestern University

**Herbert Rothman**, P.E. Adjunct Associate Professor of Civil Engineering B.S.C.E., Rensselaer Polytechnic Institute

**Sri K. Sinha**, P.E., Adjunct Associate Professor of Civil Engineering B.S.C.E. Patna University; M.S., CCNY

**Andre Touma**, P.E. Adjunct Associate Professor of Civil Engineering B.S.C.E. Damascus University (Syria); M.S. Imperial College (England); Ph.D., Duke University

**Murray Weber**, P.E. Adjunct Associate Professor of Civil Engineering B.C.E. CCNY; M.C.E., Polytechnic Institute of Brooklyn

**Irwin Weinbaum**, P.E. Adjunct Associate Professor of Civil Engineering B.C.E., CCNY

**Louis D'Amico**, Adjunct Assistant Professor of Civil Engineering  
B.S.C.E., Polytechnic Institute of New York

**Paul Cohen**, Adjunct Assistant Professor of Transportation  
B.A., City College of New York; M.S. University of Illinois

**Kamal A. Gadalla**, P.E. Adjunct Assistant Professor of Civil Engineering  
B.S.C.E., Alexandria University; M.S.C.E., Engr., Polytechnic Institute of New York

**William F. Graner**, P.E. Adjunct Assistant Professor of Environmental Engineering  
B.S.C.E., Ph.D., Polytechnic Institute of New York; M.C.E., New York University

**Paul W. Grosser**, P.E. Adjunct Assistant Professor of Civil Engineering  
B.E., M.E., Stevens Institute of Technology; Ph.D., Polytechnic Institute of New York

**Agemmemnon Koutsospyros**, Adjunct Assistant Professor of Environmental Engineering  
Dipl. E. Chem. Eng., National University of Athens (Greece)  
M.S.C.E., Ph.D., Polytechnic University

**Ahmad Rahimian**, Adjunct Assistant Professor of Civil Engineering  
B.S.S.E., Arya-Mehr University of Technology (Iran); M.S.C.E., Ph.D., Polytechnic Institute of New York

**Gabriel D. Rossetti**, P.E., P.P. Adjunct Assistant Professor of Civil Engineering  
B.S.C.E., New England College  
M.S.C.E., M.S. (Management)  
Polytechnic Institute of New York

**Michael J. Sakala**, P.E., Adjunct Assistant Professor of Environmental Engineering  
B.S., Drexel University  
M.S.C.E., Polytechnic Institute of New York

**Zohreh Shahvar**, Adjunct Assistant Professor of Civil Engineering  
B.S. (Agr. E.) University of Tehran (Iran); M.S. (Water Resources); Ph.D. (Agr. E.), Iowa State University

**Nicholas Ayoub**, P.E. Lecturer in Civil Engineering  
B.S.C.E., M.S.C.E., University of Buffalo

**Edward E. Lockley**, P.E. Lecturer in Civil Engineering  
B.S.C.E., Polytechnic Institute of New York  
M.S., M.P.A., Long Island University

**Richard Newhouse**, P.E., Lecturer in Transportation  
B.S., M.S., Polytechnic University

**Gennaro E. Sansone**, Lecturer in Transportation  
B.S.E.E., Kansas State University;  
M.B.A., Iona College

**David Sampson**, Lecturer in Transportation  
B.A., Colby College;  
M.S., Harvard University

**Raymond Schaeffer**, Lecturer in Transportation  
B.S.(CE), M.S.(Transportation),  
Swiss Federal Institute of Technology

# COMPUTER ENGINEERING

The Computer Engineering Program is an interdepartmental program administered jointly by the Departments of Electrical Engineering and Computer Science within the School of Electrical Engineering and Computer Science. For more information about the School and Departments, consult the **Academic Departments** section found in Part I of the Catalog. The Program listings for Computer Science, Electrical Engineering, Electrophysics, Information System Engineering, and Systems Engineering may also be of interest.

The Computer Engineering Program focuses on computer system design with integrated understanding of computer hardware and software. Courses are drawn from EE and CS class, labs and projects. Students take courses in solid-state devices and circuits, microprocessors, pulse circuits, switching/logic design, and computer architecture.

Computers are used today for a variety of purposes. Office automation, financial data processing, and scientific computation are only some of the applications for computers. Computers find their way into our daily lives in many ways. For example:

- Automotive Electronics
- Image Processing
- Voice Recognition
- Digital Communications
- Automated Manufacturing
- Design of Circuits and Chips
- Air-Traffic Control Systems
- Energy Control Systems
- Robotics
- Electromedical Equipment
- Publishing
- LAN (Local Area Networks)
- Banking Systems
- Power System Analysis

Polytechnic University recognizes that people are needed to design the computers, computer-controlled systems, and devices that affect our everyday

lives. The Computer Engineering curriculum provides the fundamental knowledge and techniques that graduates will need to be competent in (1) the design of computer systems, and (2) the advanced use of computers. A computer engineer will be equally comfortable working with computer hardware and software.

The BS CompE program contains a technical concentration consisting of two technical electives and a concentration laboratory/project which allows the student to develop a professional specialization. A careful selection will stimulate learning, develop depth, prepare for continuing education, and attract prospective employers. Your project will be a mature piece of work, your own achievement, developed with the guidance of your adviser. You will prepare a proposal, create your design, test it, revise it, write a professional report, and present your results publicly. The suggestions below are examples, and many others may be constructed with adviser approval.

- Advanced Hardware Design
- Computer Communications Networks
- Control and Robotics
- Data Communications
- Microcontroller System and Interface Design
- VLSI Design
- Advanced Computer Architecture
- Artificial Intelligence and Expert Systems
- Computer Graphics
- Digital Image Processing
- Software Design and Engineering
- Computer Electronics

The B.S. (Computer Engineering) is accredited by the Accreditation Board for Engineering and Technology (ABET).

## Curriculum of Study for the Bachelor of Science Degree in Computer Engineering (for Freshmen entering in 1993 or later <sup>3, 5, 6, 7</sup>)

### FRESHMAN YEAR

No.	Subject	Hours/Week			
		Cl.	Lab.	Rec.	Cr.
<b>First Semester</b>					
HU 101	<i>Writing &amp; the Humanities I (or 103)<sup>1</sup></i>	3/6	0	0	3
EG 101	<i>Introduction to Engineering<sup>1</sup></i>	1	3	1	3
CS 200	<i>Programming Methods (Pascal)</i>	0	1	1	3
CM 101	<i>General Chem. I</i>	3	0	0	2½
CM 111	<i>General Chem. Lab (Alt Wks)</i>	0	1½	0	½
MA 106	<i>Calculus I (Harvard Method)</i>	5	0	2c	4
SL 101	<i>Freshman Seminar</i>	1	0	1	0
PE 10x	<i>Sports and Teams (Optional)</i>	0	1½	0	0
					16
<b>Second Semester</b>					
HU 200	<i>Writing and Humanities II<sup>2</sup> OR</i>	3	0	0	3
SS 104	<i>Contemporary World History<sup>1</sup></i>				
EG 102	<i>Introduction to Engineering Design<sup>1</sup></i>	1	3cd	1	3
PH 107	<i>Mechanics</i>	3	0	1	3
CM 102	<i>General Chem. II</i>	3	0	0	2½
CM 112	<i>General Chem. Lab II (Alt Wks)</i>	0	1½	0	½
MA 107	<i>Calculus II (Harvard Method)</i>	3	0	2c	4
CP 101	<i>Intro to Coop (Optional; take in sem. 1, 2 or 3)</i>	1	0	0	0
PE 10x	<i>Sports and Teams (Optional)</i>	0	1½	0	0
					16

**SOPHOMORE YEAR**

**First Semester**

SS 104	Contemporary World History <sup>1</sup> OR Writing & the Humanities II <sup>1</sup>	3	0	0	3
HU 200	Writing & the Humanities II <sup>1</sup>				
EE 101	Electric Circuits I	3c	0	1	3
MA 108	Differential Equa. & Numerical Methods	3	0	0	3
CS 201	Data Structures (Pascal)	3c	0	1	3
PH 108	Electricity, Magnetism & Fluids	3	0	1	3
PH 118	Laboratory for PH 108 (Alt Wks)	1	1	0	1/2
HU 118	Public Speaking Seminar <sup>1</sup>	1	0	0	1
PE 10x	Sports and Teams (Optional)	0	1/2	0	0
					16 1/2

**Second Semester**

HU 110	Professional Report Writing	3	0	0	3
EE 102	Elect. Circuits II	3	0	1	3
EE 192	Sophomore EE Laboratory <sup>1</sup> (Alt Wks)	1/2	1/2c	0	1
MA 109	Multidimensional Calculus	3	0	1	3
CS 205	Assembly & Machine Language	3c	0	1	3
PH 109	Waves, Optics, & Thermodynamics	3	0	1	3
PH 119	Laboratory for PH 109 (Alt Wks)	0	1/2	0	1/2
PH 234	Introduction to Modern Physics	2	0	0	2
PE 10x	Sports and Teams (Optional)	0	1/2	0	0
					18 1/2

**JUNIOR YEAR**

**First Semester**

	HU Elective I OR SS Elective I <sup>2</sup>				3
CS 236	Switching & Logic Design	3d	0	0	3
EE 109	Solid State Devices & Circuits I	4	0	0	4
EE 163	Electromagnetic Waves & Materials	3	0	0	3
EE 195	Junior EE Lab <sup>1</sup>	1	3	0	2
MA 222	Probability & Statistics (or MA 223)	3	0	0	3
PE 10x	Sports & Teams (Optional)	0	1/2	0	0
					18

**Second Semester**

	HU Elective II OR SS Elective II <sup>2</sup>				3
CS 337	Computer Architecture	3d	0	0	3
CS 212	C Programming & Software Devel.	3cd	0	0	3
EE 110	Solid State Devices and Circuits II	3cd	0	0	3
EE 296	Junior Computer Laboratory <sup>1</sup>	2	3cd	0	2
MA 153/358	Linear Alg. or Numerical Methods <sup>5</sup>	3	0	0	3
PE 10x	Sports & Teams (Optional)	0	1/2	0	0
					17

**SENIOR YEAR**

**First Semester**

	SS Elective I OR HU Elective I				3
EE 113	Solid State Pulse Circuits III	3	0cd	0	3
CS 316	Microprocessors <sup>6</sup> Computer Engineering Concentration I (Determined in consultation with CompE adviser)	3	0d	0	3
EE 271	CompE Project Planning & Presentation I <sup>1</sup>	1/2	1/2	0	1/2
EE 297	Senior Computer Lab/Project <sup>1</sup> Technical Elective with Design (or Sr Lab/Proj) <sup>1</sup>	1	6cd		3
PE 10x	Sports and Teams (Optional)	0	1/2	0	0
					18 1/2

**Second Semester**

	SS Elective II OR HU Elective II <sup>2</sup> SS Elective III <sup>2</sup>				3
CS 238	Operating Systems <sup>3</sup> Computer Engineering Concentration II (Determined in consultation with CompE adviser)	3d	0	0	3
EE 272	CompE Project Planning & Presentation II <sup>1</sup> Senior Computer Engineering Design Project <sup>1</sup>	1/2	1/2	0	1/2
PE 10x	Sports & Teams (Optional)	0	1/2	0	0
					15 1/2
					136

See Notes to Curriculum below. Superscripts above are keyed to these Notes. Courses marked "c" use Computers; "d" include Design. Each Fall and Spring, an hour is set aside for Student Colloquium, used as needed for guest speakers, job information, discussions with departments, etc.

**Notes to above BSCompE Curriculum**

(Please obtain updates of the Curriculum and Notes prior to registration, from your Departmental advising office.)

**1. Writing and Speech across the Curriculum:**

A Writing Placement Exam is required to determine the best way for you to get started.

If you are placed in HU101, you immediately take this course, and continue with the following sequence each Fall and Spring semester without a break: SS104, HU200, HU110; and you must also be sure to complete HU118 before the senior year. Similarly, if placed in HU103, follow with HU 200 (or SS 104), SS104 (or HU200), HU110; and

also take HU118. If placed in HU009, follow with HU101, SS104, HU200, HU110; and also take HU118. If placed in HU008, follow with HU103, HU200, HU110, SS104; and also take HU118.

Writing and speech will be integrated into your grade in all courses — especially Humanities, Social Science, EG101, EG102, EE192, EE195, EE296, and the Senior Laboratory and Design Project courses. The Writing-and-Speech Center sponsored by Humanities is prepared to give you extra assistance by appointment; participation will not affect your grade, unless required by your instructor.

**2. The Core Curriculum in the Humanities and the Social Sciences:**

Please see catalog section "University Degree Requirements" for further information.

**3. Engineering Ethics across the Curriculum:**

Topics in engineering ethics will be included in classes, laboratories, senior project, and seminars— including such topics as social concern, responsibility, safety, environmental impact, legality, total quality management (TQM), and other topics designed to stimulate professional maturity. We also suggest you consider a Humanities or Social Science concentration in Ethics, including possibly HU347 Ethics & Technology; HU346 Ethical Theories; SS138 Technology, Environment, and Society; SS226 Problems of American Foreign Policy, or others.

**4. Senior Laboratory and Senior Design Projects:**

The School of Electrical Engineering and Computer Science (which includes Mathematics) has facilities in such areas as CAD/VLSI, communications, computer interfacing, computerized numerical methods/statistics, control/robotics, electromagnetics/microwaves, digital signal processing, electronics, image processing, machinery/power, microcomputers, network management, optical electronics, plasmas, software design, and ultrasonics, as well as the Center for Advanced Technology in Telecommunications (CATT) and the Center for Applied Large-Scale Computing (CALC). Appropriate EE-related Senior Projects offered by other departments are also possible. Which laboratories are

## COMPUTER ENGINEERING

offered in any given year depends on the campus, and the interests expressed by a sufficient number of students.

Planning, analysis, design, ethical considerations, and (usually) testing are guided by a staff member. You will frequently work in large groups or pairs to develop interaction skills essential to good engineering; occasionally you may work individually, with adviser approval. Informal and formal written and public oral presentations will help prepare you for professional careers. To ensure that you have time to complete your work in a fully professional manner, your instructor may award the incomplete (I) grade extending 4-10 weeks beyond the last day of the semester, if your progress has been good.

### 5. Graduation Requirements:

The University requires a 2.0 grade-point average in all courses taken, and specifies other general requirements in the section "University Degree Requirements", which describes the Core Curriculum for all engineering majors — including placement procedures; HU008-009-101-103-200-110; MA105-106-107-108-109; PH107-108-118-109-119; Humanities/Social Science Concentrations; course credits by transfer, advanced-placement, and special exams available to very good students which grant credit in courses approved by your Departmental adviser.

You are also required to have grades of at least C- in EE101, EE102, CS200, CS201, CS205, CS236, and CS337 before proceeding to any course for which they are prerequisite; and a Technical GPA of 2.00 based on all courses prefixed EE, CS, or EL. Grades of C- are also required in CompE Technical Concentration courses. As a senior, you may elect certain graduate courses, provided you have a GPA of at least 2.7, B grades in related courses, and adviser permission. If you are chosen to be a Senior Honors or a BS/MS Honors Student, you may speak with your Departmental adviser to consider modifying senior requirements for outstanding educational reason.

The number and distribution of credits required for graduation that are in effect when you enter Polytechnic generally remain in effect for eight calendar years (or proportionately less for transfer students), provided you remain in good standing. As the curriculum is modified,

the Department will make every effort not to increase the number of required credits.

### 6. Good Standing, Probation, and Disqualification:

A University degree represents mature growth toward responsibility and professional achievement. Study and depth of understanding, well beyond the requirements at many high-schools, prepare you for an engineering environment after graduation. This environment encompasses, on the one hand, mutual cooperation among fellow professionals; and on the other hand, an expectation that you will contribute your share to each project — to help solve a problem which has not yet been solved. You will have no teacher to give you the "answer". You must have sufficient knowledge and reasoning ability to select from a host of reference materials that information which is applicable and correct, and to reject unprofessional data.

To remain in Good Standing in the Department, you must maintain, term-by-term, and cumulatively, a Technical GPA and a University GPA of at least 2.00; fail no courses; earn at least C- in each of the courses specified above, fulfill all course pre/corequisites, and remove any incomplete (I) grades within thirty days of the last day of final exams (but see Senior Project above). If you are facing difficulties, educational or personal, please consult your instructor or a Departmental adviser at the earliest possible time. We will try to help you.

If you do not meet these conditions, you are on Departmental Probation. Students on probation must register during regular registration, not advance registration. Probation conditions may require you to repeat courses (including courses in which you received transfer credit, and courses in which you received a grade of C or less at Polytechnic); specify your credit load and permissible withdrawals; or take other remedial programs. (If you take HU008 or HU103, and have difficulty learning English as a second language, you are permitted to fail each course once without being placed on probation — if you provide written evidence from your instructor that you have attended class and required tutoring, submitted and corrected your assignments conscientiously in timely fashion, and taken all exams.)

If you do not meet Departmental Probation requirements, or twice fail to earn the required grade in any one course, or do not conform to the University Student Code of Practice, you are subject to being Disqualified from working toward the BSEE, or taking any further EE courses. The action taken depends on your particular case. If you are Disqualified, you may appeal in writing; you may apply for readmission after two terms (Fall, Spring, or Summer) have passed, if you show evidence of improved chance of success.

Exceptions may occasionally be made, in writing, by a Departmental adviser. Feel free to discuss your situation.

### 7. Dual Undergraduate Degrees:

You may earn two undergraduate degrees, one the BSCompE and one a degree in a field not closely allied — such as mechanical engineering, environmental engineering, humanities, social sciences, physics, mathematics, or others — by attending at least one additional year, and satisfying the requirements of both degrees. If you wish the second degree to be in Electrical Engineering or Computer Science, you should consider a master's degree such as the MS EE (be sure to take EE105, EE106, EE140, EE164 for the BSCompE) or the MSCS (consult with Computer Science Department).

### 8. Advanced Technical Courses:

A Computer Engineering Concentration is required, including Senior Design Project and two additional courses chosen in consultation with your adviser to develop an area of depth and specialization. Some possible areas are suggested under "CONCENTRATIONS" below, but others may be constructed. With adviser approval, students having a coherent serious educational plan may sometimes take an advanced technical elective in place of CS238, CS316, or MA153/358. Courses may sometimes be reordered to allow for flexible scheduling on your part, or on the part of the Department. All such adjustments require that prerequisites be met.

## CONCENTRATIONS FOR THE BS CompE

**Suggested Concentrations Suitable for the BSCompE, provided prerequisites and sufficient student enrollment are met:**

**\* Advanced Computer Architecture:** Intended for those who wish to specialize in the design and development of computers and computer systems. Includes courses in computer architecture, input output systems, switching and automata, parallel processing, operating systems, and projects.

**VLSI Design:** Intended for those who wish to specialize in the design and development of integrated circuits. Includes courses in advanced digital electronics, semiconductor technology, quantum and solid state electronics, integrated circuit fabrication, and projects.

**Microcontroller Systems and Interfaces:** Intended for those who wish to specialize in the design and development of embedded systems. Includes courses in advanced digital electronics, computer architecture, switching and automata, electronics laboratory, and projects.

**\* Controls and Robotics:** Intended for those who wish to specialize in the design and development of computerized control systems and automation products. Includes courses in signals and transforms, feedback system principles, control system design, system theory and feedback control, robotics, robotics/control lab, and projects.

**\* Data Communications:** Intended for those who wish to specialize in the design and development of components and systems for data communications. Includes courses in signals, systems and transforms, principles of analog and digital communication systems, signal processing, principles of communication networks, information privacy and security, digital and data communications, and projects.

**Computer Communication Networks:** Intended for those who wish to specialize in the design and development of computer networks. Includes courses in communication networks, probability and advanced communication networks, algebraic codes, information theory, and projects.

**Digital Signal Processing:** Intended for those who wish to specialize in the design and development of digital imaging components and systems. Includes courses in digital image processing, image processing lab, linear algebra, computer vision, and projects.

**Computer Graphics:** Intended for those who wish to specialize in the design and development of components and systems for computer generated graphics. Includes courses in advanced algorithms, computer architecture, interactive computer graphics, and projects.

**Advanced Electronics:** Intended for those who wish to specialize in the design and development of computer circuitry. Includes courses in advanced digital electronics, quantum and solid state electronics, integrated circuit system design, integrated circuit fabrication techniques, semiconductor technology, and projects.

**\* Electrical Engineering:** Intended ONLY for those who wish to eventually pursue graduate studies toward an MSEE degree. Includes courses in signal systems and transforms, principles of analog and digital communication systems, electromagnetic waves and materials, VLSI fabrication techniques, and projects.

**\* Artificial Intelligence and Expert Systems:** Intended for those who wish to specialize in the design and development of artificial intelligence systems. Includes courses in artificial intelligence, pattern recognition, expert systems/knowledge engineering, computer vision, neural networks, design and analysis of algorithms, and projects.

*\* All suggested concentrations are available at the Brooklyn Campus provided there is sufficient student enrollment in specific courses. Those concentrations marked with an asterisk are available at Farmingdale Campus as well as Brooklyn. Not all of the suggested courses listed are available at both campuses.*

## COMPUTER-AIDED DESIGN

In the classroom, design principles are discussed. Sometimes the device is built in the laboratory to test it, but more often the engineer makes a mathematical simulation of very high accuracy using a computer. Circuits for the touchtone telephone were designed this way, for example.

The computer-aided design (CAD) facilities and programs available to students include SPICE for transistor circuit design; communication filter and network design; power system load flow; logic-circuit testing and simulation; integrated-circuit chip layout; control system design; image processing; optimal expansion of power systems; microwave element design; printed circuit board layout; and others as needed for courses or designed by students working on a project.

## PART-TIME UNDERGRADUATE PROGRAM

Some of the courses required in the undergraduate computer engineering program can be completed in the evening by attending classes Monday through Thursday from 5:55 p.m. to 10 p.m. (10:40 p.m. summer), on a part-time basis. Such undergraduate evening courses are offered at both the Brooklyn and Farmingdale campuses, but part-time students will have to take mostly day courses to complete the degree.

Full-time and part-time students are subject to the same academic standards. Transfer between full-time and part-time status is possible at any time.

# COMPUTER ENGINEERING

## TRANSFER STUDENTS

Articulation agreements are in place with Brooklyn College, C.W. Post, and St. John's University. Qualified students from two-year preengineering programs, such as those at liberal arts and community colleges, may fulfill the requirements for the B.S. degree in computer engineering in two additional years. Since pre-engineering programs vary, a prescribed program is not possible; consequently, students should consult with an undergraduate adviser.

Graduates of technology programs may be able to fulfill the requirements for the B.S. degree in computer engineering in two to three and a half years, depending on the scope and level of their previous education. Consult with an undergraduate adviser for details.

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 computer 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.

## THE BS/MS ACCELERATED HONORS PROGRAM

Full time students may apply for the BS/MS Accelerated Honors Program which leads to the simultaneous award of a Bachelor's and a Master's Degree. Depending on the student's preparation and objectives, completion of the two degrees may come as early as the end of three and three-quarter years of study, or as late as five years. But each program is individually designed in cooperation with a Departmental BS/MS Accelerated Honors Program Adviser to allow for varied transfer and AP credits; coop program participation; professional summer jobs and other goals consistent with an honors program.

Possible BS/MS combinations include: BS CompE (Electrical Engineering Concentration) plus MSEE; or BS CompE plus MSCS.

Admission to the program is normally made at the end of the Freshman year, based on superior admissions qualifications, and outstanding achievement during the student's first year at Polytechnic. Later admission may be considered. Each student who applies is individually interviewed. Students must complete 16-20 credits each semester; maintain 3.5 overall and technical averages, particularly in key courses; and display a record essentially free of course repetitions and withdrawals.

The required courses for the two degrees include all courses required for the individual BS and MS degrees, except that 4 technical credits for Senior Project are optional. Nine credits of Master's Thesis are usually required, and a special 11 week full-time Summer honors research project at the end of the second or third year is urged, if offered.

Acceleration may be achieved through Credit by Examination; summer course work; research participation; extra course loads; careful course sequencing; and advance Placement Credit in such courses as MA106/107 (AP Calculus BC, grade of at least 4, preferably 5); and CS200 (AP Computer Science A, grade 5; or AP Computer Science AB, grade 4 or 5). Descriptive brochures illustrate some of the possibilities available to prospective participants.

## SENIOR HONOR STUDENTS

A full-time student whose performance during the first three years is outstanding will be named 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.

## GUIDANCE FOR BS CompE STUDENTS

Your instructors will help you during hours posted on their doors, or by appointment. Extensive help is available for students taking Project or Thesis. Computer Engineering advisers will be glad to advise on courses and program adjustments resulting from academic needs or personal problems.

The Office of Special Services sponsors a peer tutoring program. The Learning Center provides drop-in tutoring in mathematics and physics. Personalized career counseling is available. No charge is made.

The Freshman Seminar, SL 101, introduces you to Polytechnic and its curricula. Many courses provide extra hours or special programs on a regular basis. These include English for foreign and other students needing additional help: HU008, HU009, HU103, HU118; MA105, MA106, 107; EG 101, 102; PH 107, 108, 109; and EE101/102 and CS200 tutorials. You are urged to join the student branch of the Association for Computing Machinery (ACM) and/or the Institute for Electrical and Electronics Engineering (IEEE), and to drop in to their lab. Many ethnic clubs help students adjust to our computer engineering program.

## INFORMATION

*Undergraduate advising handouts*, available to all students, contain further details on honors, probation, approved electives, projects, elective concentrations, course offerings 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 and computer science undergraduate offices in Brooklyn and on the Long Island campus. All students are responsible for keeping informed.

## UNDERGRADUATE COURSES

Descriptions of the undergraduate electrical engineering and computer science courses which are part of the B.S. CompE curricula can be found in the course description sections for programs in Electrical Engineering and of Computer Science.

**FACULTY**

Faculty associated with the Computer Engineering program are drawn from the Department of Electrical Engineering and the Department of Computer Science. Those with primary affiliation with the CompE program include the following:

**ELECTRICAL ENGINEERING**

**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*

**H. Jonathan Chao**, Associate Professor of Electrical Engineering  
B.S., M.S., National Chiao Tung University (Hsinchu, Taiwan); Ph.D., Ohio State University;  
*Design of VLSI chips for telecommunications*

**Douglas A. Davids**, Associate Professor of Electrophysics  
B.S., M.S., Newark College of Engineering; Ph.D., Johns Hopkins University  
*Microwave acoustics, quantum electronics*

**Farshad Khorrami**, Assistant Professor of Electrical Engineering  
BSEE, B.S. (Math), M.S. (Math), Ph.D. (EE), Ohio State University  
*Robotics, control systems*

**Seung P. Kim**, Assistant Professor of Electrical Engineering  
B.S., Seoul National University; MSEE, Korea Advanced Institute of Science and Technology; M.S. (Computer Engineering), University of Pittsburgh; Ph.D. (EE), Pennsylvania State University  
*VLSI, signal processing*

**Yao Wang**, Assistant Professor of Electrical Engineering  
B.S., M.S., Tsinghua University (Beijing); Ph.D., University of California at Santa Barbara  
*Image coding, pattern recognition*

**COMPUTER SCIENCE**

**Joel B. Snyder**, Senior Industry Professor of Electrical Engineering and Computer Science  
B.E.E., M.E.E., Polytechnic Institute of Brooklyn; P.E., (New York, Massachusetts)  
*Microprocessor systems, data acquisition and transmission, signal processing*

**Haldun Hadimioglu**, Visiting Assistant Professor of Computer Science  
B.S. (EE), M.S. (EE), Middle East Technical University (Turkey), Ph.D. (CS) Polytechnic University  
*Concurrent computer systems, computer architecture and design, parallel computation*

**Susan Flynn Hummel**, Associate Professor of Computer Science; B.S., McGill University; Ph.D., New York University  
*Computer architecture, operating systems, parallel systems*

**Willard Korfhage**, Assistant Professor of Computer Science  
B.S., Princeton; M.S., Ph.D., University of California at Los Angeles  
*Distributed system and computer networks*

**Edward Kin-Ming Wong**, Associate Professor of Computer Science and Electrical Engineering  
B.E. (EE), SUNY, Stony Brook; Sc.M. (EE), Brown University; Ph.D. (EE), Purdue University  
*Artificial intelligence, robotics*

**Zhiwei Xu**, Assistant Professor of Computer Science  
B.S., University of Electronic Science & Technology, China; M.S., Purdue University; Ph.D., University of Southern California  
*Computer architecture, expert systems*

# COMPUTER SCIENCE

Computer Science is the study of the theory and practice of how to design, build and use computers. The field of study includes the design and analysis of algorithms, principles of programming languages and compilers, operating systems, software engineering, artificial intelligence, computer organization and architecture, computational mathematics, database systems, parallel and distributed computing, computer music, and image analysis and understanding.

The faculty of the department of Computer Science is involved in research at the frontiers of many of these areas; for example, the development of techniques for the design and management of long distance communication networks, such as telephone and computer networks; the development of tools to insure that complex, critical software functions correctly without potentially devastating errors; the development of methods for robots to recognize three-dimensional objects; the development of algorithms to plan a robot's motion; the development of new data formats for storing and accessing huge amounts of scientific data gathered daily from NASA's satellites; the use of computer science techniques to predict protein structure; the development of techniques for large parallel and distributed computer systems that will supply the computing power necessary for the future's scientific challenges.

The computer science program is administered by the Department of Computer Science of the School of Electrical Engineering, Computer Science and Mathematics. Its faculty directs the degree programs in computer science and information systems engineering.

## UNDERGRADUATE PROGRAM

This program in computer science is accredited by the Computer Science Accreditation Commission (CSAC) of the Computing Sciences Accreditation Board (CSAB), a specialized accrediting body recognized by the Council on Postsecondary Accreditation (COPA) and the U.S. Department of Education.

The program in computer science offers a curriculum that prepares students for a professional career as computer scientists or graduate studies in computer science leading to research or teaching careers. The undergraduate program in computer science at Polytechnic is based on the principle that a well-rounded graduate should have a rigorous education in the fundamentals of computer science including significant exposure to the design and operation of computers, solid training in related mathematics and scientific disciplines, and a broad general education including the development of communication skills.

## OVERVIEW OF THE UNDERGRADUATE CURRICULUM

This description of the curriculum is designed to give students an overview of the structure of the curriculum and to help them understand the reasons behind the design of the curriculum. Undergraduates in computer science at Polytechnic University have the advantage of being in a department with a strong graduate division. This means that the undergraduate students study in a rich intellectual environment where many of their instructors are engaged in state-of-the-art research. This significantly contributes to the quality of education and provides highly motivated undergraduates with the opportunity to engage in advanced projects with first-rate researchers.

Computer Science is not considered to be an engineering department, and we are not obligated to follow the Core Curriculum. However, we support the goals of the Common Freshman Year and have designed a set of CS requirements that are compatible with the Common Freshman Year in the Core. We have also modified our program to include the new/revised mathematics and basic science courses, and made minor changes to the Sophomore, Junior and Senior years. We believe that the new CS BS program will make it easier for freshmen who are undecided about their majors to switch into CS in their later years.

For further details and descriptions of the core program and the courses that compose the core see the section of this catalog entitled "University Degree Requirements".

### *The Computer Science Component* (43 credits)

One of the distinctive features of the computer science component is the balance of emphasis on subjects related to the design of computers and theoretical computer science. For example, students study switching and digital systems, computer organization and architecture, as well as data structures, software development, database systems, operating systems, C -language, advanced algorithms, and the principles of programming languages. The Department believes that this balance of emphasis is important in preparing graduates for a professional or research career.

Students entering Polytechnic have diverse levels of computer experience so the Computer Science Department has established two different levels of the introductory CS 200 ( Introduction to Programming Methodology): inexperienced and experienced. The experienced level is designed for students who already know some of the basics, such as keyboards, simple prompts, input/output, variables and simple loops, and therefore

would be bored if these were covered slowly. The inexperienced course will be paced for first time users and will go more slowly through the basic material. The continuation of this course, CS 201 (Data Structures and Algorithms) may also be divided into two levels of material presentation to correspond to the experience and abilities of the students.

### ***The Mathematics Component***

*(14 to 20 credits)*

Mathematics is essential to the CS curriculum. It forms the basis for understanding computer architecture and organization, principles of programming languages, algorithms, compilers, and operating systems. The mathematics sequence is designed to enhance the integration of mathematics with the computer science component. If students did not have a chance to learn high school math well (as determined by the Polytechnic placement examination in mathematics), they will be placed in a precalculus course to prepare them for the calculus sequence. The physics sequence begins in the second term of the freshman year to take advantage of their preparation in mathematics.

### ***Basic Science Component***

*(13 to 16 credits)*

Basic courses in physics and chemistry provide a well-rounded education in science. Computer scientists find that their training in basic science plays an important role in their career, by allowing them to understand the theoretical principles of new devices.

### ***Basic Engineering Component***

*(6 credits)*

Today, computers are used in all disciplines of engineering. This ranges from computer simulation of wind tunnels, to computer-aided-design (CAD) of automobile parts, to loadflow analysis of electric power circuits, etc. It is important that a computer scientist can communicate with engineers from different disciplines to understand their needs. The two courses EG 101 and EG 102 (Introduction to Engineering I & II) introduce computer science students to practical design experience in various disciplines of engineering.

### ***Humanities and Social Sciences***

#### ***Component***

*(27 credits)*

Courses in the humanities and social sciences are an important part of the curriculum. Career advancement is not only based on technical skills and knowledge, it is equally based on the ability to communicate effectively and the ability to apply the wisdom that results from a serious study and appreciation of the humanities and social sciences. Thus, in addition to basic humanities and social sciences courses, the Department requires students to take LA 139 (Engineering Ethics), HU 347 (Ethics and Technology) and HU 110 (Professional Report Writing).

### ***The Technical Elective Component***

*(18 to 27 credits)*

It is important for students to have the opportunity to explore other subject areas or to delve into areas in more depth. This is the purpose of having 18 to 27 credits of approved electives. Of these, 9 credits must be selected from computer science courses. Under certain special circumstances, undergraduate students with excellent academic records may be permitted to enroll in graduate courses. Undergraduates considering this option should be aware that graduate courses are typically much more difficult than undergraduate courses. The graduate courses that best suit this option are those that have no graduate prerequisites or have only 500 level courses as prerequisites. The following undergraduate courses can be substituted for the 500 level prerequisites: CS 200 for CS 530, CS 201 for CS 540, CS 337 for CS 580, and CS 238 for CS 590. In addition to the listed prerequisites or their equivalents, permission of the academic adviser and/or the instructor is required. Computer Science is an ever changing field, so the list of approved electives are frequently updated to include selected topics courses or "hot" topics in computer technology. The current list of approved electives can be obtained from the Computer Science Department.

## ***HONORS PROGRAM***

Full-time students may apply for the BS/MS Accelerated Honors Program which leads to the simultaneous award of a Bachelor's and a Master's Degree. Depending on the student's preparation and objectives, completion of the two degrees may come as early as the end of three and three-quarter calendar years of study, or as late as five and one-half years. But each program is individually designed in cooperation with a departmental BS/MS Accelerated Honors Program Adviser to allow for varied transfer and AP credits, co-op program participation, professional summer jobs, and other goals consistent with an honors program.

Possible BS/MS combinations with CS degrees include: BSCS plus MSCS; BSCompE plus MSCS and BSEE plus MSCS.

Admission to the program is normally made at the end of the freshman year, based on superior admissions qualifications, and outstanding achievement during the student's first year at Polytechnic. Later admission may be considered. Each student who applies is individually interviewed. Students must complete 16 to 20 credits each semester, maintain 3.5 overall and technical averages, and display a record essentially free of course repetitions and withdrawals.

The required courses for the two degrees include all courses required for the individual BS and MS degrees, and all curriculum footnotes apply. Required credits are the sum of the credits for the two degrees, except that about 4 to 7 technical or free elective credits are excused. Six credits of Master's Thesis are usually required, and a special 9-week full-time Summer honors research project at the end of the second or third year is urged, if offered.

Acceleration may be achieved through summer course work; research participation; extra course loads; careful course sequencing; and advanced placement credit in such courses as MA 106/107 (AP Calculus BC, grade of at least 4, preferably 5); and CS 200 (AP Computer Science A, grade of 5; or AP Computer Science AB, grade of 4 or 5).

**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 Department requires that at least 18 credits in computer science, 9 credits of courses from the list of approved electives, and CS 395 and CS 398 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.

Courses taken at other schools may or may not be granted transfer credit based on evaluation of the content and level of material covered. Periodic reevaluation of courses at other institutions may lead to a variation in the amount of credits granted from year to year. 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. All computer science courses will be evaluated by the Computer Science Department. Transfer students must arrive and present their records for evaluation at least one week before the regular registration period for their first semester.

**DEPARTMENTAL STANDARDS, PROBATIONS, AND "I" (Incomplete) GRADE**

Engineers and computer scientists are professionals who are expected to achieve work of acceptable quality and quantity within a specified time. Similarly, Polytechnic students need to assure timely academic progress. It is this ability, the ability to work and to achieve, which is most desired by prospective employers.

To remain in good standing, Computer Science majors must satisfy the following requirements. These requirements are in addition to the University requirements for a minimum term and cumulative 2.00 grade-point AVERAGE in all courses.

The following requirements apply to all CS students:

1. An AVERAGE of "C" (2.00) or greater in all CS courses.
2. A grade of "C-" or better in the following courses: MA 106 Calculus I, MA 107 Calculus II, CS 200 Introduction to Programming Methodology, CS 201 Data Structures and Algorithms, CS 236 Switching Theory and Logic Design, CS 205 Assembly Language and Systems Programming, CS 212 C, UNIX and Software Development.
3. Students may repeat a course in which they earned a substandard grade, but no CS course may be taken more than 3 times (grades of "W" and AUDIT are not counted for the purpose of this rule).
4. A course in which a grade of "I" is received may not be used to satisfy any prerequisites, until the incomplete is resolved. See "Policies on Grading and Grades" for the University in this catalog for additional information on Incomplete grades.

Students failing to meet any of the above requirements are placed on departmental probation as a warning that they are not progressing acceptably toward their degree. Repeated failure to meet probation requirements may lead to disqualification from the undergraduate CS program and courses. If students have any questions, they should feel free to discuss them with an adviser—preferably in a timely fashion so that good solutions can be found to any problems that may arise.

**INFORMATION**

The Undergraduate Student Manual, issued to every student, contains further details on honors, probation, approved electives, 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 in Farmingdale. Each student is responsible for keeping informed.

**Curriculum for the Bachelor of Science Degree in Computer Science (for Freshman entering 1993)**

Note: Courses marked "c" require work on various computer systems. Courses marked "d" include major Design/Computer projects.

**FRESHMAN YEAR**

No.	Subject	Hours/Week			
		Cl.	Lab.	Rec.	Cr.
<b>Fall Semester</b>					
CM 101	General Chemistry I	3	0	0	2/
CM 111	General Chemistry Lab I	0	1/	0	1
CS 200	Intro to Prog Methodology	3c	0	1	3
EG 101	Introduction to Engineering I	1	3c	1	3
HU 101	Writing/Hum I (or HU 103)	3/6/0	0	0	3
MA 106	Calculus I	3	0	2	4
SL 101	Freshman Seminar	1	1	0	0
					16

**Spring Semester**

CS 201*	Data Structures/ Algorithms OR	3c	0	1	3
EG 102	Introduction to Engineering II	1	3c	1	3
HU 200	Writing and Humanities II	2	0	0	3
MA 107	Calculus II	3	0	2	4
PH 107	Mechanics	3	0	1	3
CS 203	CS Club (recommended)	1	0	0	...0
					16

**SOPHOMORE YEAR**

**Fall Semester**

CS 201*	Data Structures/ Algorithms OR Approved Elective	3c	0	1	3
CS 236	Switching Theory/ Logic Design	3d	0	0	3
HU 118	Public Speaking	1	0	0	1
MA 108	Diff. Eqns & Num. Methods OR Approved Math Elective	3	0	0	3
PH 108	Electricity, Magnetism & Fluids	3	0	1	3
PH 118	Lab for PH 108	0	1/	0	1
SS 104	Contemporary World History	3	0	0	3
					16/

**Spring Semester**

CS 212	C, UNIX/Software Development	3d	0	0	3
CS 205	Assembly/Machine Language	3c	0	1	3
HU 110	Professional Report Writing	3	0	0	3
MA 109	Multidimensional Calculus <b>OR</b> Approved Math Elective	3	0	1	3
PH 109	Waves, Optics, & Thermodynamics	3	0	1	3
PH 119	Lab for PH 109	0	1/2	0	0.75

**JUNIOR YEAR**

**Fall Semester**

CS 202	Advanced Algorithms	3	c	0	3
CS 206	Computer Design	3d	0	0	3
CS 312	Programming Languages	3	0	0	3
EA 139	Engineering Ethics	2	0	0	2
HU/SS	Concentration	3	0	0	3
MA 223	Introduction to Probability <b>OR</b> MA 222 Intro to Prob & Stat.	3	0	0	3

**Spring Semester**

CS 275	Theory of Computation	3	0	0	3
CS 306	Software Engineering	3d	0	0	3
CS 337	Comp. Architecture & Organization	3d	0	0	3
HU 347	Ethics and Technology	3	0	0	3
MA 224	Intro to Math Statistics <b>OR</b> Approved Elective if MA222 has been taken	3	0	0	3
	Approved elective				3

**SENIOR YEAR**

**Fall Semester**

CS 308	Intro to Database Systems	3d	0	0	3
CS 395	Intro to Senior Project	1	1/2	0	1
HU/SS	Concentration Elective	3	0	0	3
	Approved Elective				3
	Approved Elective				3
	Approved Elective				3

**Spring Semester**

CS 238	Operating Systems	3d	0	0	3
CS 398	Senior Project in CS		d		3
HU/SS	Concentration Elective	3	0	0	3
	Approved Elective				3
	Approved Elective				3
	Free Elective				3

Total credits required for graduation: 133

*\*CS majors are only required to take CM 101/111. The second semester of Chemistry (102/112) is optional. Students are encouraged to take CS 201 as soon as possible.*

*Note for HU/SS Courses: Students are urged to take 2 HU and 3 SS courses as specified in the Core Curriculum*

*Note for PE 10x Physical Education—Sports and Teams (All teams): Physical Education is not required, but all students are invited to participate in such activities as sports, weightlifting, karate (Brooklyn only), intramural teams, and extramural teams as many semesters, and as many times per semester as they please.*

*Note for SL101 Student Survival (Freshman I): A course on the Polytechnic experience, study suggestions, clubs and sports, curricular options, and other topics. Required for students who enter Polytechnic with fewer than six transfer or advanced standing credits, and recommended for all students during their first semester.*

*Note for Free Electives (Senior II): A Free Elective is a course given by any department, provided it does not duplicate material studied in other courses. It must advance the student's education and have department approval. The current list of approved free electives can be obtained from the CS department.*

*Note for Approved Math Electives: The current list of approved math electives can be obtained from the CS department.*

*Note for Approved Electives: Three of the approved electives must be CS courses; the current list of approved electives can be obtained from the CS department.*

**GRADUATE PROGRAMS**

The Department of Computer Science offers Master of Science and Ph.D. degree programs in Computer Science and a Master's degree program in Information Systems Engineering. (See the catalog under Information Systems Engineering for a description of that program).

The computer science MS program is intended to develop competence in a broad range of fundamental areas including data structures and algorithms, programming languages, compilers, architecture, operating systems and artificial intelligence. This degree is offered on all three campuses.

The Ph.D. program is intended to develop competence in a broad range of areas as well as expertise in one or more specific areas, critical thinking ability, and the ability to conduct independent research. Outstanding Ph.D. students are advised to apply for financial aid in the

form of teaching assistantships, research assistantships, or partial tuition remission.

**THE MASTER OF SCIENCE DEGREE IN COMPUTER SCIENCE**

**Entrance Requirements:**— For entrance into 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 knowledge of mathematics through calculus.

**Additional entrance requirements are as follows:**

1. At least one year of university-level science;
2. A working knowledge of a high-level general purpose programming language such as Pascal or C.
3. A basic understanding of computer fundamentals such as computer organization and operation, data structures, and computer architecture.

It is anticipated that students entering with a Bachelor's degree in computer science or with a Bachelor's degree in a technical area and a strong minor in computer science will satisfy the entrance requirements for the Master's degree program.

Students having superior academic credentials but lacking sufficient background are admitted in conditional status pending satisfactory completion of several individually specified preparatory courses. In some cases such students will be invited to an interview to determine the necessary preparatory courses they need to complete. Successful completion of the preparatory courses with a "B" or better average grade is a necessary condition for transfer to regular status.

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 engineering and is required for regular status. Foreign students and others for whom

## COMPUTER SCIENCE

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 accordance with Polytechnic regulations published in the catalog. A maximum of nine units may be applied to the MS degree from previous graduate work at an acceptable institution.

### ***Master's Degree Requirements:***

To satisfy the requirements for the Master's degree, the student must complete a total of 36 units as described below, with an overall average of B. In addition, a B average is required in the "core course" group, as indicated below.

Students with an exceptionally strong undergraduate computer science background may be allowed to replace required courses with more advanced electives. Permission of the graduate director is required.

#### **Requirements:**

##### **1. Core Requirements (B average required)**

- CS 603 Design and Analysis of Algorithms
- CS 613 Computer Architecture I
- CS 623 Operating Systems I
- CS 637 Programming Languages
- CS 641 Compiler Design and Construction I

In certain rare circumstances, and with the approval of the graduate director, other CS or EE courses may be used to fulfill the core requirement.

##### **2. Analytical Requirement**

One of the following courses:

- CS 600 Fundamentals of Computer Science
- CS 675 Theory of Computation

Students who can demonstrate a strong background in discrete mathematics will be encouraged to take CS 675 instead of CS 600. Under special circumstances, with permission of the graduate director, students who can demonstrate a strong background in discrete mathematics may be permitted to substitute a graduate math course for CS 675.

##### **3. Two one-year course sequences from the following list:**

CS 603, CS 604: Design and Analysis of Algorithms I and II

CS 606 and either CS 607 or CS 608: Software Engineering I and either Software Engineering II or Principles of Database Systems

CS 613, CS 614: Computer Architecture I and II

CS 623, CS 624: Operating Systems I and II

CS 641, CS 642: Compiler Design and Construction I and II

CS 661 and either CS 662 or CS 664 or CS 665 or CS 667: Artificial Intelligence I and either Artificial Intelligence II or Vision and Scene Analysis or Expert Systems and Knowledge Engineering or Neural Network Computing

In certain circumstances, and with the approval of the graduate director, other course sequences may be used to fulfill this requirement.

##### **4. Approved elective courses, of which a maximum of 6 units may be a thesis.**

**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. An oral defense of the Master's thesis with at least three professors in attendance is required.

### ***THE Ph.D. DEGREE IN COMPUTER SCIENCE:***

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 preliminary requirements for admission to the program include the following:

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

2. A Master's degree or one year of graduate work in an analytically-based area, and a superior academic record.

Applicants must include GRE general exam scores, two letters of recommendation, a statement of purpose, and all relevant academic records, in addition to the completed application form.

The Ph.D. program consists of 3 Parts:

- A) Courses and qualifying exams;
  - B) Selection of an adviser, survey of research area, and oral presentation of survey paper;
  - C) Preparation and defense of a scholarly dissertation which embodies an original research contribution.
- In order to maintain Ph. D. candidacy reasonable progress must be made, including taking and passing the qualifying exam in a timely manner.

#### **A) Courses and Qualifying exam**

##### **Courses:**

A minimum of 90 units of graduate work beyond the BS degree, including at least 24 units of dissertation, and at least 60 units of course work is required for the Ph.D. degree.

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. A minor concentration in an area other than computer science (a minimum of four courses).

Requirements b and c must be approved by the Department of Computer Science.

##### **Qualifying exam:**

The qualifying exam is given once a year, and consists of four parts:

- 1) Algorithms and Theory of Computation,
- 2) Architecture and Operating Systems,
- 3) Programming Languages and Compilers,
- 4) Computer Applications.

The exams are based on a reading list, available from the department. Each section of the exam is largely, but not entirely, supported by several courses. However, the reading list of the exam, not the syllabus of the supporting courses, determines the required knowledge.

Students entering Poly with a Bachelor's degree will normally take the exam within two years. Students entering Poly with a Master's degree in Computer Science are advised to take the qualifying exams within a year from entering the Ph.D. program.

### B) Choosing an adviser and the formation of a committee

After passing the qualifying exam, students should begin preparing to conduct thesis research. The first step is choosing an adviser, and agreeing on a research area. In a second step a faculty committee, chosen by the head of the program, will be formed.

To develop depth of knowledge in a specific area and to demonstrate written and oral communication skills, each Ph.D. student must write a survey paper and give an oral presentation to the committee. The committee will judge the paper based on the writing, the content, the critical thinking exhibited, the oral presentation, and the student's ability to answer questions in the area surveyed. The topic of the survey paper will be chosen in consultation with the adviser, who will also instruct the student about the format and acceptable content of the survey paper. The paper should be completed within one year of finishing the qualifying exams. In order for the student to be able to complete the survey paper requirement in a timely manner, students whose spoken or written English language skills are deficient are required to remedy these deficiencies as soon as possible. One way to do this is by taking ESL and/or public speaking courses offered by the Humanities department.

### C) Dissertation

The third, and most substantial, aspect of the Ph.D. is the thesis. The thesis must embody a significant original research contribution and must be written in accepted scholarly style. The research should be conducted in close consultation with the student's adviser and committee. It is strongly recommended that

at least one paper on the research be submitted to a refereed archival journal. When the adviser feels that sufficiently significant research results have been obtained and that the thesis has been written in an acceptable way, a thesis defense, consisting of an oral presentation by the candidate and questions by the committee, will be scheduled. Additional requirements for the Ph.D. thesis are available from the office of the Dean of Graduate Studies.

## UNDERGRADUATE COURSES

Students are advised to consult the Schedule of Classes for changes in prerequisites in effect after publication of this catalog.

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

3:0:0:3 means that the course meets for 3 lecture hours, 0 laboratory hours, and 0 recitation hours each week and that a total of 3 credits, (or units for undergraduate courses), are awarded upon successful completion of the course.

### CS 200 Introduction to Programming Methodology 3:0:1:3

Introduction to discrete mathematics including: tools, techniques, methodologies, and algorithmic language. Computers and programming; the algorithmic language; pseudocode; problem solving and program structure. Compiling, running and debugging a program. Constants, variables, data types, assignments, arithmetic expressions, input and output. Top-down design and procedures. Selection and loops. Functions. Enumerated and subrange data types. Arrays, records, sets, files. Recursion, searching, and sorting. *Prerequisite: None. Co-requisites: MA 105 or 106 (or MA 100 or 101). A "C-" grade is required if this course is used as a prerequisite.*

### CS 201 Data Structures and Algorithms 3:0:1:3

Introduction to data structures. Program specification and design. Abstract data types: stacks and queues. Dynamic storage allocation. Sequential and linked implementation of stack and queues. Topics of discrete mathematics. Selecting elements from a set, searching methods, sequential and binary. Binary trees, binary search trees and general trees. Hashing. Computational complexity. Sorting algorithms, comparison of sorting techniques and analysis. *Prerequisites: CS 200 ("C-" required); MA 105 (preferably MA 106 or MA 101). Co-requisites: MA 106 preferably MA 107 or MA 110. "C-" grade required by BSCS and BSCompE majors.*

### CS 202 Advanced Algorithms 3:0:0:3

The design, implementation and analysis of algorithms. Topics in discrete mathematics, big O notation, establishing and solving simple recurrence equations. Searching and Sorting. Balanced binary search trees. Hashing. Priority queues. Algorithms on graphs: DFS, BFS, connected components, topological sort, single-source shortest paths, all-pairs shortest paths, transitive closure, minimum spanning tree. Design paradigms: divide and conquer, dynamic programming, greedy algorithms. *Prerequisites: CS 201 ("C-" grade required by BSCS majors).*

### CS 205 Assembly Language and Systems Programming 3:0:1:3

Internal representation of numeric and character data. Machine organization and machine language programming. Assembly language, assemblers. Assembly language programming: branching, arrays, lists, arithmetic and bit manipulation, macros, stacks, subroutines, parameter passing, recursion. Linking and loading, position-independent and re-entrant code. Traps and interrupts. *Prerequisite: CS 201 ("C-" required for BSCS and BSCompE majors).*

## COMPUTER SCIENCE

### CS 206 Compilers 3:0:0:3

Grammars, lexical analysis, parsing theory and algorithms, intermediate languages, storage assignment, stack machines and run-time organization. A large programming project is required. *Prerequisites:* CS 201 ("C-" required), CS 205 ("C-" required). *Suggested co-requisites:* CS 202 (required of BSCS majors) and CS 312.

### CS 211 COBOL Programming 3:0:0:3

Computing using ANSI-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. (This course cannot be used to satisfy any degree requirements in computer science or in electrical engineering.)

### CS 212 C, UNIX, and Software Development 3:0:0:3

Programming in C in the UNIX environment. Methodology of program design. Programming style, tools, environment, documentation. Programming project. *Prerequisites:* CS 200 ("C-" required); CS 201 ("C-" required).

### CS 236 Switching Theory and Logic Design 3:0:0:3

Introduction to concepts of switching theory and digital systems. Topics in discrete mathematics including: logic and propositions, properties of sets, and Boolean algebra. Number representations, arithmetic operations, coding, combinational circuits, logical design, sequential machines, state diagrams: tables, clockmode and pulse mode systems, state reduction, machine synthesis. *Prerequisites:* CS 200 ("C-" required in CS 200 for BSCS, BSCompE, and BSEE majors), CS 205 recommended. "C-" grade is required if this course is to be used as a prerequisite.

### CS 238 Operating Systems 3:0:0:3

Overview of user interface. Process structure, creation and context switching;

system calls; process cooperation. Memory management; virtual memory. I/O management; interrupt handling. File structures: directories, fault-tolerance. Design project involving construction of portions of operating system required. *Prerequisites:* CS 205 ("C-" required), CS 337 ("C-" required), CS 212 or knowledge of C language.

### CS 240 Computer Music 3:0:0:3

Digital audio fundamentals: sound measurement, A/D and D/A conversion, frequency spectra. Fourier series and transforms, DFT and FFT algorithms, convolution, filtering. Music tuning systems, microtuning, music encoding. Computer music programming, computational requirements. Additive, subtractive, and nonlinear synthesis techniques. Introduction to speech synthesis. Reverberation, localization, and psychoacoustical effects. Stochastic algorithms for computer music composition. Digital music synthesizers, MIDI microcomputer interface programming. *Prerequisites:* CS 201, MA 109 (or MA 103), and interest in music.

### CS 275 Theory of Computation 3:0:0:3

The concept of algorithms, foundational programming languages, topics in discrete mathematics, computable functions, Gödel numbering and Church's thesis, unsolvable problems, context-free grammars for formal languages, parsing, finite automata. *Prerequisite:* CS 201 ("C-" required); CS 236 ("C-" required).

### CS 306 Software Design and Engineering 3:0:0:3

Introduces the techniques used to specify, design, test, and document medium and large software systems. Design techniques include structured programming, defensive programming, program design language (PDL), and program complexity models. Path testing, exhaustive test models, and construction of test data. Software reliability models. Introduction to software tools and management techniques. Student term projects involve group software development. *Prerequisites:* CS 201 ("C-" required), CS 212 ("C-" required); MA 223 or MA 222, and CS 202 are recommended.

### CS 308 Introduction to Database Systems 3:0:0:3

The effective management and utilization of data. Objectives of a Database Management System (DBMS). The three-level architecture, data independence. File organization and access methods. Relational systems, SQL language, data definition and manipulation, views. Relational model theory, relational algebra and calculus. The database environment, transactions, concurrency, security and data integrity. *Prerequisite:* CS 212 or CS 312.

### CS 312 Principles of Programming Languages 3:0:0:3

Principles and program styles associated with current conventional programming languages. Topics include language evaluation criteria and historical influences on language design; lexical analysis, syntax analysis; semantic considerations; control structures; data types; subprograms; process and data abstractions; procedural, functional, and other language styles. *Prerequisite:* CS 201 ("C-" required).

### CS 316 Microprocessors 3:0:0:3

Block diagram description of the architecture of a typical microprocessor. Registers and ALU of the CPU. Interfacing components, bus structure, I/O techniques, priority interrupt schemes. Program techniques. *Prerequisite:* CS337 ("C-" required).

### CS 337 Computer Architecture and Organization 3:0:0:3

Computer architecture: machine language instruction set design. Computer organization: logical modules, registers, memories, I/O devices. Arithmetic and logical operations, fixed and floating point systems. Introduction to a hardware description language. Design and analysis of a complete digital computer employing hardwired and microprogrammed control. Stack machines. *Prerequisite:* CS 205 ("C-" required for BSCS and BSCompE majors), CS 236 ("C-" required).

**CS 391-4 Selected Topics in Computer Science** 3:0:0:3

Advanced courses in computer science given to selected students. These courses are vehicles for presenting novel material, trying new educational methods and courses, and taking advantage of the special competencies of visiting staff. *Prerequisite: Permission of CS Department.*

**CS 395 Introduction to Senior Project** 1:0:0:1

Group lectures and individual discussions to prepare students for professional achievement in their senior project. This is the first phase of a project (or projects) which requires the design, construction, testing, and documentation of a piece of equipment, software package, or systems applications. *Prerequisites: HU 110 ("C" required), HU 118 or HU 120, completion of all technical and lab courses through the junior year. Co/Prerequisites: All courses specified by the project adviser.*

**CS 398 Senior Project in Computer Science** 1:6:0:3

Term project. A student or several students work as a group with a staff member and graduate students on a topic of interest. Written report and presentation required. *Prerequisites: CS 395. Co/Prerequisites: All courses specified by the project adviser.*

**PREPARATORY COURSES**

2½:0:0:3 means that the course meets for 2½ lecture hours, 0 laboratory hours, and 0 recitation hours each week and that a total of 3 credits, (or units for undergraduate and graduate courses), are awarded upon successful completion of the course.

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 engineering or other graduate degree programs administered by the Department of Computer Science. Submission of substantial computer programming assignments is required in all these courses.

**CS 530 Introduction to Computer Science** 2½:0:0:3

Introduction to discrete mathematics. Computers and programming; running a program under UNIX; the algorithmic language; pseudocode; problem solving and program structure. Constants, variables, data types, assignments, arithmetic expressions, input and output. Top-down design and procedures. Selection and loops. Functions. Enumerated and subrange data types. Arrays, records, sets. Recursion, searching, and sorting. *Prerequisite: graduate status.*

**CS 540 Data Structures and Algorithms** 2½:0:0:3

Introduction to data structures. Program specification and design. Abstract data types; stacks and queues. Dynamic storage allocation. Sequential and linked implementation of stacks and queues. Searching methods, sequential and binary. Binary trees, binary search trees and general trees. Hashing. Computational complexity. Sorting algorithms: Selection sort, Insertion sort, Heapsort, Mergesort, and Quicksort. Comparison of sorting techniques and analysis. *Prerequisite: CS 530.*

**CS 580 Computer Architecture and Organization** 2½:0:0:3

This course provides computer science students with an understanding of computer hardware subsystems, and basic digital design tools and strategies. Combinational and sequential circuits are developed for the basic building blocks of computers. Binary and hexadecimal arithmetic is presented in both human and machine algorithms. A simple computer is built up from the building blocks developed. Hardwired and microprogrammed control systems are investigated. Assembly language and instruction sets are presented. Memory organization alternatives are explored. *Prerequisite: graduate status. Corequisite: CS 530.*

**CS 590 Introduction to Operating Systems** 2½:0:0:3

This course describes operating systems, the programs that interface with computer hardware. These programs can be implemented in firmware or software. The concept of process as "program in execution" is introduced, and operations (suspend and resume) on processes discussed. Hardware and software mechanisms for providing asynchronous processes with mutually exclusive access to resources and for avoiding deadlocks are given. Scheduling strategies for CPU- and IO-bound process are described. Storage management is presented as the second major component of an operating system. The organization of physical storage is discussed. The implementation of virtual memory and of file systems is described. The importance of security and protection in multi-user systems is discussed. A case study may be presented. *Prerequisites: CS 530 and CS 580.*

**GRADUATE COURSES**

Graduate courses in computer science are offered on each campus on a regular basis, annually, or in two or three-year cycles. The Computer Science Graduate Mailing, sent out to students prior to each registration, contains the latest information on course offerings for the semester, including descriptions of Selected Topics courses offered.

2½:0:0:3 means that the course meets for 2½ lecture hours, 0 laboratory hours, and 0 recitation hours each week and that a total of 3 credits, (or units for undergraduate and graduate courses), are awarded upon successful completion of the course.

**CS 600 Foundations of Computer Science** 2½:0:0:3

This course is intended to help students develop the background they will need in order to master more advanced material encountered later and covers the following topics: Mathematical induction, algorithms, proof of correctness of programs, Sets, relations and functions.

## COMPUTER SCIENCE

Combinatorics, probability (probability spaces, inclusion/exclusion, random variables, moments, binomial distribution). Difference equations, propositional logic, truth tables, DNF and CNF. Trees and graphs. Formal machines (automata and regular expressions, grammars). Rates of growth of functions, intractable problems.

### CS 603 Design and Analysis of Algorithms I 2/1:0:0:3

Data structures: priority queues, binary search trees, height-balanced trees, heaps, hash tables. Searching and sorting techniques: heapsort, quicksort, sorting in linear time, medians and order statistics. Design and analysis techniques: dynamic programming, greedy algorithms. Graph algorithms: elementary graph algorithms (breadth-first search, depth-first search, topological sort, connected components, strongly connected components), minimum spanning tree, shortest path. *Prerequisites: CS 540, CS 600.*

### CS 604 Design and Analysis of Algorithms II 2/1:0:0:3

Advanced design and analysis techniques: amortized analysis of algorithms. Advanced data-structures: binomial heaps, Fibonacci heaps, data structures for disjoint sets, analysis of union by rank with path compression. Graph algorithms: elementary graph algorithms, maximum flow, matching algorithms, randomized algorithms. Theory of NP-completeness and approach to finding (approximate) solutions to NP-complete problems. Selected additional topics that may vary. *Prerequisite: CS 603.*

### CS 606 Software Engineering I 2/1:0:0:3

Software development and modeling tools. Software architecture, requirements, design, validation, reliability estimation, and management. Top-down, object-oriented, modular and domain-specific design. Design representation techniques. Specification-based and program-based testing techniques. Error reliability and mean-time-between failure models. Team programming and programming in the large. *Prerequisites: CS 540*

### CS 608 Principles of Database Systems 2/1:0:0:3

Database management system overview. Data independence and abstraction. Physical database organization, and access methods. Data models, the Entity-Relationship model, the network, hierarchical and relational models. Relational Database design, functional dependencies and normalization. Query processing and optimization. Concurrency control and recovery. Security and integrity. Distributed and Object-oriented databases. *Prerequisites: CS 308 or permission of instructor, CS 600.*

### CS 613 Computer Architecture I 2/1:0:0:3

Uniprocessor computer architectures: performance and cost, instruction set design and measurements, basic processor implementation techniques, simple pipeline techniques, memory hierarchy design, and computer arithmetic. *Prerequisite: CS 580.*

### CS 614 Computer Architecture II 2/1:0:0:3

Computer architectures that exploit parallelism: pipelining, super-scalar, vector processors, overview of parallel machines, and selected parallel computing topics, such as, MIMD and SIMD machines and their interconnection structures. *Prerequisite: CS 613.*

### CS 616 Microprocessors 2/1:0:0:3

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 618 Fault-Tolerant Computers 2/1:0:0:3

Introduces a variety of hardware and software techniques for designing and modeling fault-tolerant computers. Topics include: coding techniques (Hamming, SECDED, SECCDED, etc.); majority voting schemes (TMR); software redundancy (N-Version programming); software recovery schemes; network reliability design and estimation.

Introduces probabilistic methods for reliability modeling. Examples from space fault-tolerant systems, networks, commercial non-stop systems (TANDEM and STRATUS). Fault-tolerant modeling tools such as HARP, ARIES, SHURE. *Prerequisite: CS 236 or CS 580.*

### CS 623 Operating Systems I 2/1:0:0:3

Operating systems for uniprocessors: processes, mutual exclusion, job scheduling, memory, storage hierarchy, file systems, and analytical modeling of computer systems. *Prerequisite: CS 590.*

### CS 624 Operating Systems II 2/1:0:0:3

Operating systems for parallel and distributed computers: concurrent programming, process synchronization, deadlocks, distributed computing, networks, distributed concurrency control, and analytical modeling of computer systems. *Prerequisite: CS 623.*

### CS 627 Performance Evaluation of Computer Systems 2/1:0:0:3

Modeling and performance analysis of computer systems. Introduction to queuing network models and elements of queuing analysis. Exact and approximate analytical techniques, simulation and operation 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 637 Programming Languages 2/1:0:0:3

The structures, notations, and semantics of conventional programming languages. Issues of scoping, binding, type structure, and parameter passing. Abstract data types. Programming in the large. Language support for parallelism. Implementation issues. Functional, logic and object-oriented languages. *Prerequisites: CS 540.*

### CS 641 Compiler Design and Construction I 2/1:0:0:3

Compiler organization. Lexical analysis, syntax analysis, abstract syntax trees,

symbol table organization, code generation. Introduction to code optimization techniques. *Prerequisites: CS 540, CS 580, CS 600.*

**CS 642 Compiler Design and Construction II** 2%:0:0:3

Further considerations of syntactic analysis, semantic analysis and code optimization techniques. *Prerequisite: CS 641.*

**CS 653 Interactive Computer Graphics** 2%:0:0:3

This course introduces students to the fundamentals of computer graphics. Topics covered include: graphics softwares and hardwares, window-to-viewport mapping, 2-D clipping, dynamic techniques, interactive techniques, 2-D and 3-D transformations, viewing transformation, 3-D rendering, 3-D clipping, Z clipping, raster graphics, space curves and surfaces, hidden line removal, etc. *Prerequisites: CS 540 and MA 153, or equivalents.*

**CS 661 Artificial Intelligence I** 2%:0:0:3

This course introduces students to the many concepts and techniques in Artificial Intelligence (AI). Topics covered include: problem spaces and search, heuristic search techniques, predicate logic, game playing techniques, planning, learning, natural language processing, and machine perception.

**CS 662 Artificial Intelligence II** 2%:0:0:3

Further study of automation of intellectual processes. Automatic theorem proving. Expert systems. Simulation of verbal learning behavior. Learning machines, adaptive systems, robots, decision-making problems. Adequacy of existing theoretical treatments. *Prerequisite: CS 661.*

**CS 664 Computer Vision and Scene Analysis** 2%:0:0:3

This course introduces students to the many techniques, applications and current research areas in computer vision and scene analysis. Topics include: polyhedral scene analysis, early process-

ing, image segmentation (edge detection and region growing), 2-D and 3-D geometric structure representation, 3-D object recognition, depth measurement and analysis, image motion analysis, and model-based and knowledge-based vision systems. *Prerequisites: CS 540 and MA 153, or equivalents, or permission of instructor.*

**CS 665 Expert Systems and Knowledge Engineering** 2%:0:0:3

This course introduces students to the various techniques used in building an expert system. An introduction to the rule-based programming language OPS5 will be given, and a prototype expert system will be built using it. Topics covered include: knowledge representation methods, production systems, inference procedures, uncertainty and evidence combination, expert systems architectures and control, knowledge acquisition, programming languages for expert systems, and various case studies. *Prerequisites: CS 661 and programming experience.*

**CS 667 Neural Network Computing** 2%:0:0:3

An introduction to neural network models and their applications. Discussion of organization and learning in neural network models including: Perceptrons, Adalines, backpropagation networks, recurrent networks, adaptive resonance theory and the neocognitron. Implementations in general and special purpose hardware, analog and digital. Application in various areas with comparisons to non-neural approaches. Decision systems, nonlinear control, speech processing and vision. *Prerequisite: CS 540. Some familiarity with matrix notation and partial derivatives is recommended.*

**CS 671 Switching and Automata I** 2%:0:0:3

Analysis and synthesis of combinational and sequential switching circuits. Boolean algebras, 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: CS 600.*

**CS 675 Theory of Computation** 2%:0:0:3

Computability and decidability. Computable and primitive recursive functions. The Halting Problem. Recursively enumerable sets. Relationships between languages, grammars, and machines. Solvable and unsolvable linguistic questions. *Prerequisite: CS 600 or permission of instructor.*

**CS 681 Information, Privacy, and Security** 2%:0:0:3

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 682 Network Management and Security** 2%:0:0:3

Human aspects of network management; performance measures; classical and vendor network management systems; unified systems; OSI network management; fault and performance; configuration control; security; encryption. *Prerequisite: EL 635.*

**CS 901-912 Selected Topics in Computer Science** each 2%:0:0:3

Topics of current interest in computer science. Recent offerings include software specification and validation, parallel algorithms and architectures, distributed systems, randomized algorithms, object oriented programming in C++, advanced topics in databases, performance analysis, computational optimization. (See computer science graduate mailing for detailed description of each particular offering). *Prerequisite: specified when offered.*

## COMPUTER SCIENCE

**CS 941-942 Readings in Computer Science I, II** *each 2 1/2:0:0:3*

Intended primarily for advanced graduate students who wish to study in a specialized area under the supervision of a faculty member. Permission of graduate director is required. Regular meetings with the adviser. An examination or term report required. *Prerequisite: regular graduate status.*

**PROJECT AND THESIS: STUDENTS MAY REGISTER AND MAY GET CREDIT FOR THESE COURSES MORE THAN ONCE.**

**CS 996 Advanced Project in Computer Science** *2 1/2:0:0:3*

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 adviser 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 are 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 Department.*

### **THE FOLLOWING COURSES ARE OFFERED AS PART OF THE INFORMATION SYSTEMS ENGINEERING PROGRAM:**

**CS 630 Input and Output Systems** *2 1/2:0:0:3*

The theory, technique and technology of interaction between electronic digital information systems and the external environment from a systems perspective. Models of text, speeches, and images useful for systems studies. The processes and devices to convert between text, speech, and image representations of information and electronic digital information systems. *Prerequisite: regular graduate status.*

**CS 676 Mathematical Techniques for Information** *2 1/2:0:0:3*

Basic results from queuing theory, data structures and graphs and network flows. Poisson processes, M/M/1, M/G/1 queues. Queuing networks. Linked lists, sorting, searching, dynamic storage management. Graphs and network flows, spanning trees; algorithmic complexity, linear programming, network flows, min-cut max-flow. *Prerequisites: regular graduate status, EL 531, and MA 103.*

**CS 907 Human Factors in Information Systems** *2 1/2:0:0:3*

This course will introduce students to human behavioral issues in the design and use of interfaces for information systems. Basic issues of behavioral research and evaluation methods will be discussed. Sensory systems, memory and learning theory relevant to systems human factors will be reviewed and related to specific interface issues, such as interaction devices, dialogue design, and reference material. The focus will be on understanding the issues involved in creating systems amenable to human use. *Prerequisite: Graduate standing.*

## FACULTY

**Gad M. Landau**, Associate Professor of Computer Science and Head of the Computer Science Department  
B.Sc. (Math, CS), M.S., Ph.D.(CS), Tel-Aviv University (Israel)  
*Algorithms, string matching, computational biology, pattern recognition, communication network*

**Ivan T. Frisch**, Professor of Electrical Engineering and Computer Science and Provost  
B.S. (Physics), Queens College; B.S. (EE), M.S. (EE), Ph.D. (EE), Columbia University  
*Information systems, computer networks and network control*

**Donald Hoekney**, Professor of Computer Science and Director of the Center for Applied Large-Scale Computing  
B.A., McMaster University; Ph.D. (Philosophy), Cornell University  
*Logic, network design and applications, data base systems*

**Richard Mandelbaum**, Professor of Mathematics; B.S., Rensselaer Polytechnic Institute; M.A., Ph.D., Princeton University  
*Networking protocol*

**Henry Ruston**, Professor of Electrical Engineering and Computer Science  
B.S.E. (Math), B.S.E. (EE), University of Michigan; M.S. (EE), Columbia University; Ph.D. (EE), University of Michigan  
*Software engineering, programming languages*

**Martin L. Shooman**, Professor of Electrical Engineering and Computer Science  
S.B., S.M. (EE), 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  
B.S. (Physics), Stanford University; Ph.D. (Operations research), University of California (Berkeley)

*Combinatorial optimization, information network design, algorithms*

**Phyllis G. Frankl**, Associate Professor of Computer Science  
B.A. (Math, Physics), Brandeis University; M.A., (Math), Columbia University; M.S., Ph.D. (CS), New York University.  
*Software testing and analysis*

**Jeanette P. Schmidt**, Associate Professor of Computer Science  
B.Sc. (Math, CS), Hebrew University of Jerusalem; M.S. (CS), Ph.D. (CS), Weizmann Institute of Science, Rehovot, Israel  
*Data structures, randomized algorithms, probabilistic analysis, computational biology*

**Edward K. Wong**, Associate Professor of Computer Science  
B.E. (EE), SUNY, Stonybrook; Sc.M. (EE), Brown University; Ph.D. (EE), Purdue University  
*Computer vision, image analysis, pattern recognition*

**Susan Flynn Hummel**, Associate Professor of Computer Science  
B.A. (Math), McGill University; Ph.D. (CS) New York University  
*Parallel software and hardware*

**Boris Aronov**, Assistant Professor of Computer Science  
B.A. (Math, CS), Queens College, CUNY; M.S., Ph.D. (CS), New York University  
*Algorithms, computational and combinatorial geometry*

**Willard Korfhage**, Assistant Professor of Computer Science  
B.S.E. (EE/CS), Princeton University; M.S., Ph.D. (CS), University of California at Los Angeles  
*Distributed systems, operating systems, queuing theory*

**Vassilis J. Tsotras**, Assistant Professor of Electrical Engineering and Computer Science  
B.A. (EE/CS), National Technical Univ. of Athens (Greece); M.Sc. (EE), M.Phil. (EE), Ph.D. (EE), Columbia University  
*Database systems, access methods, parallel databases and computer networks*

**Joel Wein**, Assistant Professor of Computer Science  
B.A. (Applied Mathematics), Harvard University; Ph.D. (Applied Mathematics), Massachusetts Institute of Technology  
*Parallel and distributed computation, combinatorial optimization, scheduling theory, algorithms, network optimization*

**(Bill) Zhiwei Xu**, Assistant Professor of Computer Science  
B.S. (CS) University of Electronic Science and Technology (China); M.S. (CompE), Purdue University; Ph.D. (CompE), University of Southern California  
*Computer architecture, parallel programming*

**Linda Anne Grieco**, Coordinator of Advising  
B.A. (Math), Hofstra University; M.S. (CS), Polytechnic Institute of New York; Ph.D. (Math), Rutgers University  
*Programming and computer software*

**Haldun Hadimioglu**, Visiting Assistant Professor of Computer Science  
B.S. (EE), M.S. (EE), Middle East Technical University (Turkey), Ph.D. (CS) Polytechnic University  
*Concurrent computer systems, computer architecture and design, parallel computation*

**Mohammed Ghriga**, Instructor in Computer Science  
Dipl. d'Ingénieur (CS) de l'Université des Sciences et de Technologie d'Alger (Algérie); M.S. (CS), Polytechnic University  
*Software engineering, theory of computation, communications software*

## INDUSTRY PROFESSORS

**Robert J. Flynn**, Industry Professor of Computer Science  
B.S. (Physics), Manhattan College; M.S. (Math), Ph.D. (Math), Polytechnic Institute of Brooklyn  
*Computer architecture, operating systems*

**Barry Jones**, Industry Assistant Professor of Electrical Engineering and Computer Science  
B.S. (EE), Cooper Union; M.S. (EE), Marist College  
*Electromechanical systems, real-time computer systems*

## ADJUNCT FACULTY

**Maurice Karnaugh**, Distinguished Adjunct Professor  
B.S. (Physics), City College of New York; M.S., Ph.D., Yale University

**David R. Doucette**, Adjunct Professor  
B.S., M.S., Ph.D., Polytechnic Institute of Brooklyn

**Barry V. Gordon**, Adjunct Professor  
B.E.E., M.E.E., New York University

**Edward Lancevich**, Adjunct Professor  
B.E.E., City College of New York, CUNY; M.S. (EE), Columbia University; Ph.D. (EE), Polytechnic Institute of NY

**Gary Tjaden**, Adjunct Professor  
B.S. (E.E.) University of Utah; M.S. (E.E.) Northwestern University; Ph.D. (C.S.) John Hopkins University

**Walter Vasilaky**, Adjunct Professor  
B.A. (Math), Rutgers University; M.A. (Applied math), University of Maryland; Ph.D. (Applied math), NY University

**Eric Walthers**, Adjunct Professor  
B.A., Ph.D. (Philosophy), Yale University

**Arthur Appel**, Adjunct Associate Professor  
B.M.E., M.M.E., City College of New York

**Lillian S. Ruston**, Adjunct Associate Professor  
S.B. (EE), Massachusetts Institute of Technology; M.S. (EE), Ph.D. (EE), Polytechnic University

## COMPUTER SCIENCE

**Kenneth R. Aupperle**, Lecturer  
B.S., M.S., Polytechnic Institute of New York

**Mohammed Feknous**, Lecturer  
Ingeniorat en Electronique (E.E.), Ecole Nationale Polytechnique d'Alger; M.S. (E.E.) University of Missouri - Rolla

**John Kaufman**, Lecturer  
B.A. (CS), New York University; M.S. (CS), Polytechnic University

### EMERITUS FACULTY

**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. (Physics), California Institute of Technology; M.A. (Physics), Ph.D. (Physics), Harvard University  
*Computer languages and algorithms, computer software*

**Stanley Preiser**, Professor of Mathematics and Computer Science

B.S. (Physics), City College of New York; M.S., Ph.D. (Math), New York University

*Numerical analysis, theory of computation, applied mathematics, software engineering*

**Edward J. Smith**, Professor Emeritus of Electrical Engineering

B.E.E., Cooper Union; M.E.E., D.E.E., Polytechnic Institute of Brooklyn  
*Computer organization, switching and automata*

# ELECTRICAL ENGINEERING

## THE SCHOOL OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE

The School of Electrical Engineering and Computer Science was formed in 1990 to coordinate the academic and research programs of the Electrical Engineering Department and the Computer Science Department. These activities trace their beginnings to Polytechnic's first electrical engineering program in 1886. The earliest emphasis on electrical power generation, distribution, and lighting expanded to radio communications in the early 20th century; microwaves, radar, and television in the 1940's; and digital computers in the 1950's.

In addition to the recognized excellence in teaching, textbook writing, and research achievements of its faculty and students, the School has a long tradition of close ties with engineering practice in industry and government. Leaders from industry serve on advisory boards for the School's programs, and it has served the life-long learning needs of working engineers since part-time graduate programs were initiated in 1926.

As an administrative unit, the School fosters interdepartmental cooperation in the many areas where EE and CS have common interests, including the BS program in Computer Engineering, and graduate student research in the Centers for Advanced Technology in Telecommunications (CATT), Applied Large Scale Computing (CALC), and Imaging Sciences (IIS). The School's faculty and graduate students also participate in the electrophysics research associated with the Weber Research Institute (WRI), founded as the Microwave Research Institute in the 1940's by Dr. Ernst Weber, who later became head of the EE department, and then President of Polytechnic.

The centers and the degree programs in electrophysics, system engineering, computer engineering, computer science, and information systems engineering are described in more detail elsewhere in this Catalog.

## THE DEPARTMENT OF ELECTRICAL ENGINEERING

The Department of Electrical Engineering administers a variety of degree programs summarized in the table which follows. 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 1993 Gourman Report shows Polytechnic EE programs as best in the New York City area and highly-ranked nationally, 12th for B.S. and 13th for M.S. 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. All of these programs are offered by The Department of Electrical Engineering within the School of Electrical Engineering and Computer Science. For more information about the School and the Departments consult the Academic Departments section found in Part I of this Catalog. The program listings for computer engineering, computer science, electrophysics, information system engineering, and system engineering may also be of interest. The graduate programs in electrophysics and in system engineering are described in the appro-

priate 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 engineering and computer engineering, are described in other sections of the Catalog. The departmental faculty also participates in the graduate programs in energy, imaging sciences, and telecommunications management, described elsewhere in the Catalog.

**Degree Programs Administered by the Department of Electrical Engineering are:**

### UNDERGRADUATE

#### Electrical Engineering

- Bachelor of Science

#### Computer Engineering

- Bachelor of Science (page 94)

(Administered jointly with Department of Computer Science)

### GRADUATE

#### Electrical Engineering

- Master of Science
- Doctor of Philosophy

#### Electrophysics

- Master of Science
- Doctor of Philosophy

#### Systems Engineering

- Master of Science

**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 telecommunications, radio, television, computers and healthcare. Because of the advances electrical engineers have brought about in power distribution, computers and communications, the world is a far different place than it was a mere 100 years ago. Their inventions have made the world a smaller safer place. Reporting and images from distant places make world events part of our life.

While undergraduate and graduate students in electrical engineering concentrate on these areas, graduates eventually apply their training to such diversified fields as bioengineering, city planning, astronautics, 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; speech and image processing; electrooptics and electro-acoustics; microwave engineering; personal communications; power systems and energy conversion; plasma science and engineering; system and control engineering; quantum electronics; and materials 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), is accredited by the Accreditation Board for Engineering and Technology (ABET).

**Curriculum of Study for  
the Bachelor of Science  
Degree in Electrical  
Engineering (for  
Freshman entering in  
1993 or later) 3, 5, 6, 7**

**FRESHMAN YEAR**

No.	Subject	Hours/Week			
		Cl.	Lab.	Rec.	Cr.
<b>First Semester</b>					
HU 101	Writing and the Humanities I <sup>1</sup> (or HU 103)	3(6)	0	0	3
EG 101	Introduction to Engineering <sup>1</sup>	1	3cd	1	3
CS 200	Programming Methodology (Pascal)	3c	0	1	3
CM 101	General Chem. I	3	0	0	2/
CM 111	General Chemistry Lab I (Alt Wks)	0	1/	0	1/
MA 106	Calculus I (Harvard Method)	3	0	2c	4
SL 101	Freshman Seminar	1	0	1	0
PE 10x	Sports and Teams (Optional)	0	1/	0	0
					16

**Second Semester**

HU 200	Writing and the Humanities II <sup>2</sup> OR	3	0	0	3
SS 104	Contemporary World History <sup>1</sup>				
EG 102	Introduction to Engineering Design <sup>1</sup>	1	3cd	1	3
PH 107	Mechanics	3	0	1	3
CM 102	General Chem. II	3	0	0	2/
CM 112	General Chemistry Lab II (Alt Wks)	0	1/	0	1/
MA 107	Calculus II (Harvard Method)	3	0	2c	4
CP 101	Intro to Coop (Optional; take sem 1,2or3)	1	0	0	0
PE 10x	Sports & Teams (Optional)	0	1/	0	0
					16

**SOPHOMORE YEAR**

**First Semester**

SS 104	Contemporary World History <sup>1</sup> OR	3	0	0	3
HU 200	Writing & the Humanities <sup>1</sup>				
EE 101	Electric Circuits I	3c	0	1	3
MA 108	Differential Eqns & Numerical Methods	3	0	0	3
CS 201	Data Structures (Pascal)	3c	0	1	3
PH 108	Electricity, Magnetism & Fluids	3	0	1	3
PH 118	Laboratory for PH 108 (Alt Wks)	0	1/	0	1/
HU 118	Public Speaking Seminar <sup>1</sup>	1	0	0	1
PE 10x	Sports & Teams (Optional)	0	1/	0	0
					16/

**Second Semester**

HU 110	Professional Report Writing I	3	0	0	3
EE 102	Elect. Circuits II	3	0	1	3
EE 192	Sophomore EE Laboratory (Alt Wks) <sup>1</sup>	1/	1/	0	1
MA 109	Multidimensional Calculus	3	0	1	3
CS 205	Assembly & Machine Language	3c	0	1	3
PH 109	Waves, Optics & Thermodynamics	3	0	1	3
PH 119	Laboratory for PH 109 (Alt Wks)	0	1/	0	1/
PH 234	Introduction to Modern Physics	2	0	0	2
PE 10x	Sports and Teams (Optional)	0	1/	0	0
					18/

**JUNIOR YEAR**

**First Semester**

HU Elective I OR					
SS Elective F					
CS 236	Switching & Logic Design	3d	0	0	3
EE 105	Signals, Systems & Transforms	3	0	0	3
EE 109	Solid State Devices and Circuits I	4	0	0	4
EE 163	Electromagnetic Waves and Materials	3	0	0	3
EE 195	Junior EE Lab I <sup>1</sup>	1	3	0	2
PE 10x	Sports and Teams (Optional)	0	1/	0	0
					18

**Second Semester**

HU Elective II OR					
SS Elective II <sup>2</sup>					
CS 337	Computer Architecture <sup>6</sup>	3d	0	0	3
EE 106	Feedback System Principles	3cd	0	0	3
EE 110	Solid State Devices & Circuits II	3cd	0	0	3
EE 164	EM Fields & Radiation	3	0	0	3
EE 296	Junior Computer Laboratory <sup>1</sup>	2	3cd	0	2
PE 10x	Sports and Teams (Optional)	0	1/	0	0
					17



## 6. Good Standing, Probation, and Disqualification.

A University degree represents mature growth toward responsibility and professional achievement. Study and depth of understanding, well beyond the requirements at many high-schools, prepare you for an engineering environment after graduation. This environment encompasses, on the one hand, mutual cooperation among fellow professionals; and on the other hand, an expectation that you will contribute your share to each project — to help solve a problem which has not yet been solved. You will have no teacher to give you the “answer.” You must have sufficient knowledge and reasoning ability to select from a host of reference materials that information which is applicable and correct, and to reject unprofessional data.

To remain in Good Standing in the Department, you must maintain, term-by-term, and cumulatively, a Technical GPA and a University GPA of at least 2.00; fail no courses; earn at least C– in each of the four courses specified above; fulfill all course pre/corequisites; and remove any incomplete (I) grades within thirty days of the last day of final exams (but see Senior Project above). If you are facing difficulties, educational or personal, please consult your instructor or a Departmental adviser at the earliest possible time. We will try to help you.

If you do not meet these conditions, you are on Departmental Probation. Students on probation must register during regular registration, not advance registration. Probation conditions may require you to repeat courses (including courses in which you received transfer credit, and courses in which you received a grade of C or less at Polytechnic); specify your credit load and permissible withdrawals; or take other remedial programs. (If you take HU008 or HU103, and have difficulty learning English as a second language, you are permitted to fail each course once without being placed on probation — if you provide written evidence from your instructor that you have attended class and required tutoring, submitted and corrected your assignments conscientiously in timely fashion, and taken all exams.)

If you do not meet Departmental Probation requirements, or twice fail to earn the required grade in any one course, or do not conform to the University Student Code of Practice, you are subject to being Disqualified from working toward the BSEE, or taking any further EE courses. The action taken depends on your particular case. If you are Disqualified, you may appeal in writing; you may apply for readmission after two terms (Fall, Spring, or Summer) have passed, if you show evidence of improved chance of success.

Exceptions may occasionally be made, in writing, by a Departmental adviser. Please feel free to ask.

## 7. Dual Undergraduate Degrees:

You may earn two undergraduate degrees, one the BSEE and one a degree in a field not closely allied — such as mechanical engineering, environmental engineering, humanities, social sciences, physics, mathematics, or others — by attending at least one additional year, and satisfying the requirements of both degrees. If you wish the second degree to be in Computer Engineering or Computer Science, you should consider a master’s degree such as the MSEE (with EL/CS/MA electives emphasizing your interests) or the MSCS.

## 8. Advanced Technical Courses:

With adviser approval, students having a coherent serious educational plan may sometimes take an advanced Technical Elective in place of EE113, EE140, EE180, or CS337. In Brooklyn, courses may be delayed to allow a Technical Elective to be taken in Senior Semester One. In Farmingdale, EE180 will be offered in Senior Semester Two, and one of the EE/CS Technical Electives moved to Senior Semester One. All such adjustments require that prerequisites be met.

Recent senior project topics include:

- *Modes of a Laser with Intracavity Frequency Doubler*
- *In-Building Propagation of UHF Signals*
- *Neural-Type Optimization*

- *Continuous Phase-Modulation Digital Signaling*
- *Compact, Low-Field, High-Harmonic Gyrotron*
- *Pulsed Hollow-Cathode Lasers*
- *Flashover in Crossed Electric and Magnetic Fields*
- *Small-Scale Model of Coilgun*
- *Power Electronics*
- *Picosecond Optoelectronics for Ultrashort Pulses*
- *Numerical Methods for Optical Microscopy*
- *Morphological Analysis and Coding of Images*
- *Radar and Sonar Signal Processing*
- *Telecommunication Management Workstation*
- *Expert System for Computer Music*
- *Hardware Design of a DSP Processor*
- *Digital Simulation of an Analog System*
- *Computer-Aided Instruction for Digital Signal Processing*
- *Local Area Networks (LAN)*
- *The Processing of Images from Incomplete Data*
- *Wireless Information Networks*

## COMPUTER-AIDED DESIGN

In the classroom, design principles are discussed. Sometimes the device is built in the laboratory to test it, but more often the engineer makes a mathematical simulation of very high accuracy using a computer. Circuits for the touch-tone telephone were designed this way, for example.

The computer-aided design (CAD) facilities and programs available to students include SPICE for transistor circuit design; communication filter and network design; power system load flow; logic-circuit testing and simulation; integrated-circuit chip layout; control-system design; image processing; optimal expansion of power systems; microwave element design; printed-circuit-board layout; and others as needed for courses or designed by students working on a project.

### **PART-TIME UNDERGRADUATE PROGRAM**

Some of the courses required in the undergraduate electrical engineering program can be completed in the evening by attending classes Monday through Thursday from 5:55 p.m. to 10 p.m. (10:40 p.m. summer), on a part-time basis. Such undergraduate evening courses are offered at both the Brooklyn and Farmingdale campuses, but part-time students will have to take most of their courses during the day to complete the degree.

Full-time and part-time students are subject to the same academic standards. Transfer between full-time and part-time status is possible at any time.

### **TRANSFER STUDENTS**

Qualified students from two-year pre-engineering programs, such as those at liberal arts and community colleges, may fulfill the requirements for the B.S. degree in electrical engineering in two additional years. Since pre-engineering programs vary, a prescribed program is not possible; consequently, students should consult with an undergraduate adviser. Articulation agreements are in place with Brooklyn College, C.W. Post, and St. John's University.

Graduates of technology programs may be able to fulfill the requirements for the B.S. degree in electrical engineering in two to three and a half years, depending on the scope and level of their previous education. Consult with an undergraduate adviser for details.

Transfer credits for courses taken at other schools are based on evaluation of content and level. 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.

### **THE BS/MS ACCELERATED HONORS PROGRAM**

Full time students may apply for the BS/MS Accelerated Honors Program

which leads to the simultaneous award of a Bachelor's and a Master's Degree. Depending on the student's preparation and objectives, completion of the two degrees may come as early as the end of three and three-quarter years of study, or as late as five years. But each program is individually designed in cooperation with a Departmental BS/MS Accelerated Honors Program Adviser to allow for varied transfer and AP credits; co-op program participation; professional summer jobs and other goals consistent with an honors program.

Possible BS/MS combinations include: BSEE plus MSEE, MS (Electrophysics), MS (Systems Engineering), or MSCS.

Admission to the program is normally made at the end of the Freshman year, based on superior admissions qualifications, and outstanding achievement during the student's first year at Polytechnic. Later admission may be considered. Each student who applies is individually interviewed. Students must complete 16-20 credits each semester; maintain 3.5 overall and technical averages, particularly in key courses; and display a record essentially free of course repetitions and withdrawals.

The required courses for the two degrees include all courses required for the individual BS and MS degrees, and all curriculum footnotes apply. Required credits are the sum of the credits for the two degrees, except that 4 technical credits are excused. Nine credits of Master's Thesis are usually required, and a special 11-week full-time Summer honors research project at the end of the second or third year is urged, if offered.

Acceleration may be achieved through Credit by Examination; summer course work; research participation; extra course loads; careful course sequencing; and Advanced Placement Credit in such courses as MA106/107 (AP Calculus BC, grade of at least 4, preferably 5); and CS200 (AP Computer Science A, grade 5; or AP Computer Science AB, grade of 4 or 5).

Descriptive brochures illustrate some of the possibilities that are available to prospective participants.

### **SENIOR HONOR STUDENTS**

A full-time 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.

### **GUIDANCE FOR BSEE STUDENTS**

Your instructors will help you during hours posted on their doors, or by appointment. Extensive help is available for students taking Project or Thesis. Electrical Engineering advisers will be glad to advise on courses and program adjustments resulting from academic needs or personal problems.

The Office of Special Services sponsors a peer tutoring program. The Learning Center provides drop-in tutoring in mathematics and physics. Personalized career counseling is available. No charge is made.

The Freshman Seminar, SL 101, introduces you to Polytechnic and its curricula. Many courses provide extra hours or special programs on a regular basis. These include English for foreign and other students needing additional help; HU008, HU009, HU103, HU118; MA105, MA106, 107; EG 101, 102; PH 107, 108, 109; and EE101/102 and CS200 tutorials. You are urged to join the student branch of the Institute for Electrical and Electronics Engineering (IEEE), and to drop in to their lab. Many ethnic clubs help students adjust to our electrical engineering program.

### **INFORMATION**

*Undergraduate advising handouts*, available to all students, contain further details on honors, probation, approved electives, projects, elective concentrations, course offerings 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 and computer science undergraduate offices in Brooklyn and on the Long Island campus. All students are responsible for keeping informed.

## GRADUATE PROGRAM

The Department of Electrical Engineering offers graduate programs leading to the degrees of master of science 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 information systems engineering.

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. For up-to-date information, please refer to the EE Department Graduate Student Manual, which is revised annually and is available from the EE Graduate Office.

Outstanding students should apply for financial aid in the form of research fellowships, teaching fellowships, or partial tuition remission.

**Information Science** — Information science deals with 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.

**Signal Processing** — Signal processing deals with the generic problem of extracting the useful/desired information (signal) from the received data in the presence of uncertainties such as noise and other distortions. The techniques are applicable to any information processing situation and they involve analysis and design of signals, channels, and receiving systems as well as task-oriented signal processing algorithms.

**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 engineer, they are trained in the fields of automation and system theory. Typical examples of control systems are automatic guidance systems for aircraft and space vehicles, electric motor control, and chemical process control.

**Electronics and Networks** — The discipline of electronics and networks involves the design, construction, and theoretical treatment of circuits used in modern electronic equipment, particularly those involving semiconductor devices and integrated circuits.

**Fields and Waves** — Studies in fields and waves include electromagnetic and acoustic wave radiation and propagation under a variety of conditions, including nonlinear, anisotropic, and periodic media. Such studies include microwave waveguides and antennas, optical fibers and integrated optics, diffraction and scattering effects, surface and bulk acoustic wave propagation, and transduction. Applications include radar, microwave and optical communications, and surface acoustic wave technology.

**Plasma and Atmospheric Physics** — This area is involved with breakdown and ionization of gases and the interaction of the resultant plasma with electromagnetic waves. Such studies have application to the propagation of high power radio waves in the atmosphere and 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 electromagnetic propulsion for space rockets.

**Quantum Electronics and Materials Science** — Quantum electronics and materials science deal with the interaction of electromagnetic fields and waves with matter. The theoretical basis of this area requires a quantum treatment but many aspects can be understood without specific use of quantum methods of analysis. Topics of interest include lasers, electro-optics, optical communication devices, and electric, magnetic and thermal properties of materials.

## REQUIREMENTS FOR THE MASTER OF SCIENCE 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.

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 undergraduate and introductory level graduate electrical engineering courses. Such graduate courses count toward the master's degree. A student with a B.S. degree in a field other than electrical engineering may also want to consider the departmental master's degree programs in electrophysics or in system engineering.

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 point 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 630	<i>Probability</i>
EL 625	<i>Linear Systems</i>
EL 611	<i>Signals, Systems and Transforms</i>
EL 641	<i>Advanced Electronic Circuitry I</i>
EL 671	<i>Fields and Waves</i>
CS 613	<i>Computer Architecture I</i>

9 Units

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 Units

3. Approved electives, which may include a thesis (9 units) and one reading course (3 units maximum).

24-15 Units  
Total: 36 Units

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 EE Department *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 either of the departmental prefixes EL or CS): A maximum of 12 units of approved courses may be taken as electives.

**Thesis:** An exceptional student may elect to write a master's thesis for which 9 units toward the degree may be earned. Such a student should find an appropriate adviser who has agreed to monitor the thesis research. The research 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.

### REQUIREMENTS FOR THE DOCTOR'S OF PHILOSOPHY DEGREE

**General** — Graduate students who have exhibited a high degree of scholastic proficiency and have given evidence of ability for conducting independent research may consider extending their goals towards the doctorate. The degree of Ph.D. is awarded to a student who completes the program of studies and research described below, and prepares and defends a dissertation representing an original and significant contribution worthy of publication in a recognized scientific or engineering journal. For a more complete description of the topics summarized here, please refer to the latest EE Graduate Student Manual.

**Admission to Programs** — Entrance into the doctoral program of study and research is contingent on the candidate's passing the departmental qualifying examination and forming a guidance committee (both described below). A student entering with a bachelor's degree will normally take the qualifying examinations after one year of study. Entering students holding master's degrees may take these examinations as soon as they are prepared, but full-time students 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. These examinations are divided into two sections: (a) a written examination requiring preparation through the first-year graduate level in several areas related to the student's principal area of interest; and (b) an oral examination concentrating mainly on

this principal area. Principal areas of concentration are: communications, signal processing, systems and control, electronics, electro-optics, electromagnetics, and network and optimization, and power. Students interested in the related area of electrophysics should refer to the corresponding Ph.D. program described under that title.

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 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 students' 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 adviser certify this in writing to the Office of Research and 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. Candidates in EE must take a minimum of 51 units in formal courses (as distinct from "independent study" units such as reading, project, or thesis) as part of the general requirement of 90 units. Ph.D. students are required to take a minimum of 12 units of courses in a minor area

outside of electrical engineering. 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 departmental handouts 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 and most sophomore requirements are completed. Knowledge of computer programming at the level of CS 200 is assumed in all EE courses. In the listing of course credits and hours, the symbol "c" indicates computer usage, and "d" signifies design.

### BASIC COURSES

#### EE 101 Electric Circuits I

3c:0:1:3

Kirchhoff and power laws. Passive and active d-c circuit elements. Node and loop analysis, voltage and current division, linearity and superposition, voltage and current division, Thevenin's and Norton's theorems. Source-free and forced responses of RL, RC and RLC circuits. *Prerequisites:* MA 107 (or 102 or 110), PH 107 (or 104); *experience in using a computer.* *Pre/Corequisites:* MA 108 (or 104) and PH 108 (or 105), PH 118 (or 115). *C- or better is required in EE 101 before proceeding to courses for which this is prerequisite.*

#### EE 102 Electric Circuits II

3:0:1:3

Continuation of EE 101. Sinusoidal steady-state response. Phasors. Average power, maximum power transfer, root-mean-square values, average power. Complex frequency, poles and zeros. Resonance. Real Fourier series. Mutual inductance. Three-phase systems. *Prerequisites:* EE 101 (C- or better required), MA 108 (or 104); PH 108 (or 105); PH 118 (or 115); *experience in using a computer.* *Pre/Corequisites:* *Highly recommended are EE 192 (or 194); PH 109 (or 106), PH 119 (or 116).* *C- or better is required in EE 102.*

#### EE 103 Signals & Transforms

4:0:0:4

Fourier series. Analog and digital systems, integro-differential equations and recursion equations with initial conditions, solutions by Laplace and z-transforms. Linear Time Invariant (LTI) systems and their input-output relations, impulse response, continuous and discrete-time convolution, causality, and stability of linear systems. Fourier transforms and frequency response of LTI systems. Discrete-time signals, systems, and their z-transforms. Digital simulator for analog systems. Stability tests for rational LTI systems. Bode plots. *Prerequisites:* *Either EE 101 (C- or better required) and EE 102 (C- or better required); or EE 370 (C- or better required); MA 108 (or 104), MA 109 (or 103).* [Replaced by EE 105 effective Fall 1994]

#### EE 105 Signals, Systems & Transforms

3:0:0:3

Complex Fourier series. Fourier Transforms: linearity, scaling, time and frequency shift, differentiation. Convolution. Band limited signals and the sampling theorem. Linearity, time-invariance, impulse response, causality. Frequency and time response of LTI systems. Transfer functions and low-, high-, and all-pass filters. Laplace transforms, inverses, and theorems; applications to time-invariant systems with initial conditions and suddenly turned-on sources. Sampled band limited signals, z-transforms, inverses, convergence, and theorems. Discrete convolution. Stability tests for rational analog and discrete systems. Concept of FIR and IIR filters. Digital simulators for analog systems. *Prerequisites:* *Either EE 101 (C- or better required) and EE 102 (C- or better required); or EE 370 (C- or better required); MA 108 (or 104), MA 109 (or 103).*

### CONTROL AND INSTRUMENTATION

#### EE 104 Feedback System Principles

3d:0:0:3

Introduction to analysis and design of continuous, linear feedback control systems. Modeling of physical systems, Signal Flow Graphs and Mason's Gain

Formula, sensitivity and steady-state error, Routh-Hurwitz and Nyquist stability tests. The use of root locus and frequency response techniques to analyze system performance and design compensation to meet performance specifications. Realistic design problems. *Prerequisite: EE 105 (or 103), PH 108 (or 105).*

[Replaced by EE 106 effective Fall 1994]

**EE 106 Feedback System Principles**  
3cd:0:0:3

Introduction to analysis and design of linear feedback control systems. Modeling of physical systems. Signal Flow Graphs and Mason's Gain Formula, sensitivity and steady-state error, Routh-Hurwitz and Nyquist stability tests. The use of root locus and frequency response techniques to analyze system performance and design compensation to meet performance specifications. Realistic design problems. *Prerequisite: EE 105 (or 103), PH 108 (or 105). Formerly called EE 104.*

**EE 107 Control System Design**  
3:0:0:3

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 106 (or 104).*

**ELECTRONIC CIRCUIT  
ANALYSIS AND DESIGN**

**EE 109 Solid State Devices and Circuits I**  
4:0:0:4

Semiconductor fundamentals. Physics of junction diodes. Diode circuits and applications: rectifiers, voltage regulators, clipper circuits. Physics and device models for Bipolar Junction Transistors (BJT) and Field Effect Transistors (JFET and MOSFET), including Ebers-Moll equations, large-signal analysis, operating modes, and switching times. Single-

stage midband amplifier analysis: Q-point selection, stabilization, small-signal models, and circuit analysis. Fabrication of integrated circuits. *Prerequisites: EE 102 (C- or better required); PH 108 (or 105); PH 234. Corequisites: preferably EE 195 and EE 163 (or 165). (Alternate Prerequisites: A- or better in EE 101; B or better in PH 108 (or 105); B or better in PH 234; Corequisite: EE 102.)*

**EE 110 Solid State Devices and Circuits II**  
3cd:0:0:3

Small-signal analysis and design of transistor amplifiers at low, midband, and high frequencies. Computer-aided analysis and design. Operational amplifier building blocks: differential amplifiers, current sources, level shifters, output stages. Op-Amp examples. Applications of feedback to electronic circuits. *Prerequisites: EE 109; Pre/Corequisites: preferably EE 195, EE 163 (or 165).*

**EE 113 Solid-State Devices and Circuits III**  
3cd:0:0:3

Transient response of piecewise linear single energy storage element networks, switching speeds of diodes and transistors, diode wave-shaping networks, switching speeds of diodes and transistors, analysis and design of digital logic integrated circuits; voltage sweep circuits; monostable, astable, and bistable multivibrators. *Prerequisite: EE 110, EE 195. Pre/Corequisites: preferably EE 296 (formerly called CS 296); a senior laboratory.*

**EE 115 Advanced Digital Electronics**  
3d:0:0:3

Flip-flops, shift registers, counters, arithmetic operations, semiconductor memories, switches, A/D converters D/A converters, and selected applications of digital circuits. *Prerequisite: EE 113; EE 195. Pre/Corequisites: preferably EE 296 (formerly called CS 296); a senior laboratory.*

**EE 116 Communication Electronics**  
3d:0:0:3

Design and analysis of small-signal and large-signal tuned amplifiers, sine-wave oscillators, mixers, AM modulators and

demodulators, FM modulators and demodulators, phase-locked loops. *Prerequisites: EE 110; EE 195. Pre/Corequisites: preferably EE 113; a senior laboratory.*

**EE 119 Semiconductor Technology**  
3:0:0:3

Principal techniques involved in processing and fabrication of semiconductor devices and integrated circuits including material preparation, junction forming, circuit integration and packaging. *Prerequisites: EE 110; EE 195. Pre/Corequisites: preferably EE 113; a senior laboratory.*

**EI. 545-546 Microwave Integrated and Semiconductor Circuits I, II\***  
Each 2½:0:0:3

See graduate course listings.

**COMMUNICATIONS AND  
INFORMATION  
TRANSMISSION**

**EE 140 Principles of Analog and Digital Communications**  
3:0:0:3

Principles and techniques for modern communications systems. Analog and digital signals, sampling, quantization, signal representation. Analog and digital modulation, pulse code modulation, time and frequency multiplexing. Noise in communication systems. *Prerequisites: EE 105 (or EE 103); EE 109; MA 223.*

**EE 141 Signal Processing** 3cd:0:0:3

Spectral representations of discrete-time signals and the Fast Fourier Transform. Random discrete-time signals and spectral analysis. Detection and estimation of signals in noise. Adaptive filtering and linear mean square estimation. Computer projects involving applications of signal processing. *Prerequisites: CS 200, MA 223, EE 105 (or 103); EE 140.*

**ELECTROMAGNETIC  
FIELDS**

**EE 163 Electromagnetic Waves and Materials**  
3:0:0:3

One dimensional electromagnetic wave propagation in free space and dispersive

## ELECTRICAL ENGINEERING

dielectrics. Governing equations are motivated by considering distributed inductance and capacitance on transmission lines. Electromagnetic plane waves are obtained as a special case. Reflection and transmission at discontinuities is discussed for pulsed sources and related to power flow. Classical models of motion for free charges in conductors and bound charges in dielectrics are introduced to explain dispersion in materials, and its influence on the electrical and optical properties of materials. *Prerequisites: EE 102 (C- or better required) or EE 370 (C- or better required); PH 108 (or 105); PH 109 (or 106); MA 108 (or 104); MA 109 (or 103). Pre/Corequisites: preferably PH 234. First offered Spring 1994.*

### **EE 164 Electromagnetic Fields and Radiations** 3:0:0:3

This course relates the electromagnetic fields to their sources in charges and currents. Starting with static charges and steady currents, and progressing to time-dependent sources, Maxwell's equations are developed. Radiation from antennas is treated, along with wave guiding by conducting and dielectric waveguides. *Prerequisite: EE 163. (EE 165 is not an acceptable prerequisite). First offered Fall 1994.*

### **EE 165 Electromagnetic Fields and Waves I** 3:0:0:3

Electrostatic fields in vacuum. Gauss's law, potential, and capacitance. Magnetostatic fields in vacuum, Ampere's law, and inductance. Faraday's law and Maxwell's equations. Plane waves, transmission lines, and the propagation and reflection of waves. *Prerequisites: EE 102 (C- or better required) or EE 370 (C- or better required); PH 108 (or PH 105); PH 109 (or 106); MA 108 (or 104); MA 109 (or 103). Last offered Fall 1993.*

[Replaced by EE 163 effective Spring 1994.]

### **EE 166 Electromagnetic Fields and Waves II** 3:0:0:3

Conductors, dielectrics, magnetic materials, and boundary conditions. Plane waves in dielectrics. Transmission-line impedance transformation, and standing waves. Rectangular conducting wave

guides. Radiation from dipoles and arrays. *Prerequisites: EE 165 (EE 163 is not an acceptable prerequisite). Last offered Spring 1994.*

[Replaced by EE 164 effective Fall 1994.]

### **EL 571-572 Engineering Electromagnetics I, II**

See graduate course listings.

### **EL 573 Introduction to Microwave Engineering** 2½:0:0:3

See graduate course listings.

## **ELECTRONIC MATERIALS SCIENCE**

### **EE 167 Quantum and Solid State Electronics** 3:0:0:3

Review of experimental necessity for introduction of quantum states and wave-particle dualism elements of wave mechanics and quantum statistics. Application to electronic structure of atoms, periodic table, properties of electrons in metals, semiconductors, insulators. Laser systems. *Prerequisite: PH 234; EE 109. Pre/Corequisite: EE 164 (or 166).*

### **EL 551-552 Electro-Optics I, II** Each 2½:0:0:3

See graduate course listings.

### **EL 557 Introduction to Electric and Magnetic Properties of Solids** 2½:0:0:3

See graduate course listings.

## **ELECTRIC POWER**

### **EE 180 Electrical Machinery I** 3:0:0:3

Description, theory, and analysis of steadystate performance for the four types of electrical machine: transformer, induction motor, synchronous machine, and d-c machine. Equivalent circuits and vector diagrams derived and used as the primary tools for analysis. Power majors should take EE 180 in Junior Spring, EE 204 in Senior Fall, and EE 205 in Senior Spring. *Prerequisites: EE 163 (or 165).*

*Pre/Corequisite: EE 164 (or 166).*

### **EE 181 Electrical Machinery II** 3:0:0:3

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. *Prerequisites: EE 180; EE 164 (or 166) Pre/Corequisite: preferably EE 204.*

### **EE 183 Electric Power Systems** 3:0:0:3

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, and economic dispatch. Computer exercises on power load flows. *Prerequisites: EE 102 (C- or better required); EE 180. Pre/Corequisite: EE 204 is suggested.*

### **EL 564 Electromechanical Power Conversion\***

See graduate course listings.

### **EL 568-569 Electric Drives I, II**

See graduate course listings.

### **EL 581 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 192 Sophomore EE Laboratory** ½:1½:0:1

Experiment in instrumentation and electric circuits. Use of SPICE. *Prerequisite:*

sites: EE 101 (C- or better required), PH 108 (or 105) PH 118 (or 115); preferably HU 110. Pre/Corequisite: EE 102. Meets alternate weeks. [First offered Fall 1994, at which time EE 193 and 194 will be discontinued.]

**EE 193 Sophomore Electrical Engineering Laboratory I**

1/2:1 1/2:0:1

Introduction to electrical measurements. Use of SPICE. Lab fee required. Prerequisites: MA 107 (or 102 or 110); PH 107 (or 104); preferably HU 200. Pre/Corequisites: EE 101 (C- or better required, or coregistration in EE 101); PH 108 (or 105); PH 118 (or 115). Meets alternate weeks. Withdrawal from EE 101 requires withdrawal from EE 193. Last offered Spring or Summer 1994.

**EE 194 Sophomore Electrical Engineering Laboratory II**

1/2:1 1/2:0:1

Electrical circuits laboratory. Use of SPICE. Lab fee required. Prerequisites: EE 101 (Grade C- or better) and EE 193, PH 108/105. Pre/Corequisite: EE 102 (C- or better required, or coregistration in EE 102); preferably HU 110. Withdrawal from EE 102 requires withdrawal from EE 194. Last offered Spring or Summer 1994.

**EE 195 Junior Electrical Engineering Laboratory**

1:3:0:2

Circuits and electronics laboratory. Lab fee required. This course is part of Writing-and-Speech-across-the-Curriculum. Prerequisites: EE 194, EE 102 (Grade C- or better); PH 118 (or 115); HU 200. Co/Prerequisite: EE 109, HU 110.

**EE 196 Senior Electrical Engineering Laboratory I**

1:3:0:2

Experiments in electronics, control, and electromagnetic waves. Lab fee required. This course is part of Writing-and-Speech-across-the-Curriculum. Prerequisites: EE 110; EE 192 (or 194); EE 195, HU 110; preferably EE 296 (or CS 296). Pre-Corequisite: EE 106 (or 104); EE 163 (or 166); suggested EE 113. Last offered Spring or Summer 1994; replaced by EE 200 beginning Fall 1994.

**EE 296 Junior Computer Laboratory**

2:3:0:2

[Replaces CS 296 Computer Laboratory I, effective Spring 1994.]

A series of required experiments provides an introduction to small computers: digital and analog circuit techniques, small computer assembly and programming, minicomputer and microcomputer organization and operations. Lab fee required. Prerequisites: CS 205 (C- or better required for CompE majors); CS 236 (C- or better required); EE 109 (or EE 370); EE 195 (or EE 374); HU 110. Pre/Corequisites: CS 337. Offered Spring or Summer.

**Senior Laboratory/Project and Senior Design Projects**

All EE and CompE majors develop their professional competence by taking a Senior Laboratory/Project (3 credits); and a Senior Design Project (3 credits). EE majors accompany the course selected as their Design Project with a concurrent course EE 260 Project Planning and Presentation (1 credit, 1 semester) - which, depending on the topic, may be split into EE 261 in the preceding semester and EE 262 in the concurrent semester, to allow time for project planning. For CompE's, the appropriate course number is EE 270 (or 271 and 272). You carefully plan for Senior Lab/Projects and Design Project by completing any required prerequisites (one of the Lab/Projects may often be a prerequisite for the Design Project), and by taking any corequisites.

In particular, the course designated as your Senior Design Project presents a special challenge in planning, designing and testing/checking, including both technical and socio-ethical considerations. To be sure that your Design Project is professional, you may receive an incomplete (I) grade extending no more than 10 weeks beyond the last day of final exams, provided the instructor deems that the work achieved by the semester's end represents good progress and diligence. All senior labs and projects are part of Writing-and-Speech-across-the-Curriculum, and technically competent, clear, written and oral reports are essential.

Seniors are invited and urged to take additional Senior Lab/Projects or Design

Projects as senior electives, to develop practical and professional understanding. If you select a second Design Project course, you will prepare reports, but are usually excused from EE 260/270 and the full professional report.

Please consult the EE Advising Bulletin Board for further information on the campus, year, and semester for all courses. Offering of laboratories and projects is contingent on sufficient student registration. All EE laboratory and project courses, sophomore through senior, have lab fees. Course EE 200 may be used to replace EE 196; other Laboratory/Projects may also be used with adviser permission.

**EE 200 General Senior EE Laboratory/Project**

1 1/2:4 1/2:0:3

Experiments in electronics, control, and electromagnetic waves. Miniproject. Course is part of Writing and Speech across the Curriculum. Prerequisites: EE 110, EE 106 (or 104), EE 164, EE 195, HU 110, HU 118 (or 119 or 120), and preferably EE 296 (or CS 296). Pre/Corequisite: EE 113. [First offered Fall 1994, at which time EE 196 will be discontinued.] Offered Fall and Spring.

**EE 202 Senior Electronics Laboratory/Project**

3

Experiments in analog, digital, and communications electronics — including a two-stage amplifier design with SPICE simulation, FM modulators, multivibrator and timing circuits, active filters, large-signal tuned amplifiers, sine-wave oscillators, and phase-locked loops. Miniproject. Prerequisites: EE 110; EE 195; EE 296 (or CS 296); HU 110; HU 118 (or 119 or 120); Pre/Corequisite: EE 113. Offered Fall 1993 and Spring 1994; thereafter offered Fall.

**EE 204 Senior Machinery Laboratory/Project**

3

Experiments on basic power devices—including the transformer, the d-c machine, the induction motor, and the synchronous machine. Miniproject. Prerequisites: EE 163 (or 165); EE 180 (preferably taken in Junior II by power majors); EE 195; HU 110, HU 118 (or 119 or 120); preferably EE 296 (or CS 296). Pre/Corequisite: EE 164 (for students who took EE 163). If possible,

# ELECTRICAL ENGINEERING

meets one-day-a-week in Brooklyn, so that Farmingdale students may attend. Offered Fall and Spring.

## **EE 206 Senior Semiconductor Laboratory/Project** 3

Experiments and projects on the fabrication of PMOS transistors, starting with a blank silicon wafer, mask generation, lithography, oxidation, diffusion, metalization, and encapsulation. Test and analysis of completed packages. If possible meets one-day-a-week in Farmingdale, so that Brooklyn students may attend. *Prerequisites:* EE 110; EE 163 (or 165); EE 195; HU 110, HU 118 (or 119 or 120); EE 296 (or CS 296). *Pre/Corequisites:* Usually EE 119 or 167, and EE 113.

## **EE 208 Senior Special Topics Laboratory/Project** 3

Studies and experiments related to current research or other laboratory facilities. Miniproject. *Prerequisites:* Completion of the technical courses and laboratories of the junior year; HU 110; HU 118 (or 119 or 120). Other pre/corequisites to be specified. Offered Fall at Departmental discretion.

## **EE 210 Summer Honors Laboratory/Project** 3

An individual or small-group intensive 11-week research-oriented project, often related to current research. Offered in the Summer following the junior year, under the supervision of a staff member. Students using this course as their Senior Design Project register for EE 260 (EE majors) or EE 270 (CompE majors) in the following Fall, to complete professional written and oral reports, as well as further research; most of the work is to be completed by October 15. *Prerequisite:* Completion of all technical courses and laboratories of the junior year with 3.3 or greater GPA; competitive selection by the Steering Committee and Staff Sponsor; HU 110; HU 118 (or 119 or 120). Students submit an application form in the preceding Spring. Offered Summer.

## **EE 212 Senior VLSI Laboratory/Project** 3

Introduction to the design of Very-Large

Scale Integrated Circuits. The student designs a chip having hundreds of transistors, using a commercial VLSI-CAD system. If the design is satisfactory, the student registers for EE 213; has the chip fabricated, depending on the availability of equipment; designs and carries out a procedure for testing the chip thoroughly; and modifies the design. *Prerequisites:* EE 110; EE 195; EE 296 (or CS 296) with C or better grade; EE 337 (with C or better grade); HU 110, HU 118 (or 119 or 120); EE 163 (or 166). *Pre/Corequisites:* EE 113; usually EE 119 or 167. Offered Fall.

## **EE 214 Senior Robotics/Control Laboratory Project** 3

Theoretical principles germane to feedback control and robotics. Small-scale analog and/or digital control applications. Data acquisition and control through a computer. Experiments such as:

- Stabilization of an inverted pendulum (non-linear) on a cart, by accelerating the cart back and forth using various feedback-control algorithms.
- Control of a two-degree-of-freedom non-linear robot manipulator, using various algorithms.
- Pulse-width modulation technique for the control of d-c motors.
- Adaptive control algorithms and their application to a specific second-order system.

*Prerequisites:* EE 106 (or 104 or similar); EE 110 (or EE 370 for B students); EE 195; EE 296 (or CS 296); ability to program in C language; HU 110, HU 118 (or 119 or 120). *Pre/Corequisite:* preferably EE 180 and EE 113. B-or-better students from other departments should discuss prerequisites with senior EE adviser or instructor. If possible, will meet one-day-a-week in Brooklyn, so that Farmingdale students may attend. Offered Spring 1994, and Fall thereafter.

## **EE 216 Senior Image Processing Laboratory/Project** 3

Senior Projects in digital image processing using PC's equipped with special imaging hardware. Design of good test images which can demonstrate the pros and cons of implemented algorithms. Miniproject. *Prerequisites:* EE 110 (or EE 370 for B+ students); EE 195; EE

296 (or CS 296); ability to program in C language; HU 110, HU 118 (or 119 or 120). B-or-better students from other departments should discuss prerequisites with instructor. If possible, will meet one-day-a-week in Brooklyn, so that Farmingdale students may attend. Offered Spring.

## **EE 218† Senior Microwave Laboratory/Project** 3

[Cross-listed with EL 970]. See EL 970 for typical topics and additional corequisites. Miniproject. If possible, will meet one-day-a-week in Farmingdale, so that Brooklyn students may attend. *Prerequisites:* EE 105 (or 103); EE 110; EE 164 (or 166) with B- or better grade; EE 195; HU 110, HU 118 (or 119 or 120); preferably EE 296 (or CS 296). *Pre/Corequisites:* preferably EE 113.

## **EE 220 Senior Electrical Engineering Laboratory Project** 3

Individual or small-group laboratory/project under staff guidance; for EE majors. Offered only in special cases with permission of senior EE adviser. *Prerequisites:* Completion of all technical courses and laboratories of the junior year; HU 110, HU 118 (or 119 or 120). *Pre/Corequisites:* As specified by adviser. Replaces EE 399 effective Spring 1994.

## **EE 222 Senior Computer Engineering Laboratory/Project** 3

Individual or small-group laboratory/project under staff guidance; for CompE majors. Offered only in special cases with permission of senior CompE/EE adviser. *Prerequisites:* Completion of all technical courses and laboratories of the junior year; HU 110, HU 118 (or 119 or 120). *Pre/Corequisite:* As specified by adviser. Replaces CS 398 effective Spring 1994.

## **EE 297 Senior Computer System Laboratory** 1:6:0:3 [Replaces CS 297 Computer Laboratory II, effective Spring 1994.]

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. *Prerequisites:* CS 296, CS 337, CS 205, EE 110, EE 163 (beginning Fall 1995); HU 110; HU 118 (or 119 or 120). Senior Laboratory/Project required for CompE majors and elective for EE majors.

## INTERDEPARTMENTAL COURSES

### EE 370 Principles of Electrical Engineering 3:0:0:3

Electrical signals and circuit elements. Network analysis. Transient and sinusoidal steady-state analysis of first and second order circuits. Diode and transistor circuits. Digital and logic circuits. (Cannot be used to satisfy any electrical engineering degree requirements.) *Prerequisite:* MA 107 (or 102 or 110); PH 108 (or 105). *Co/Prerequisite:* MA 108 (or 104).

### EE 374 Instrumentation Laboratory 0:3:0:1

Experiments designed to supplement EE 370. Familiarization with electrical measurements, equipment, and modern electronic components. (Cannot be used to satisfy any electrical engineering degree requirements.) Lab fee required. *Prerequisite:* PH 118 (or 115); *Co/Prerequisite:* EE 370.

## DESIGN PROJECTS AND SPECIAL LISTINGS

Each design project includes planning, design, evaluation, social responsibility, quality and marketability. Projects that run in any particular semester will depend on student and staff interest. One or two semesters before these courses are offered, students will meet with staff to discuss course content, and in some cases, will contribute to the decision on which projects are to be offered.

These senior design projects may often be offered to a large group of students (12 to 25), to give experience in group planning and dynamics. The instructor will be a staff member experienced in the area of the project. Students

will concentrate on a common theme. As specified by the instructor, students may work individually or in small groups on the same design project, and then compare their different results at the end of the semester. Alternatively, the whole class may work on a single large project, where the class is divided into sub-groups, each responsible for a different part of the large project. Seminars and lectures on the chosen theme will be given.

*Prerequisites:* Completion of the junior year, an appropriate Senior Lab/Project, HU 110, HU 118 (or 119 or 120). Additional appropriate pre/corequisites will be specified semester-by-semester for each Project. May also be chosen as a technical elective. If used as a senior project, professional formal and informal written and oral reports are required as part of Writing-and-Speech across the Curriculum; in this case, EE majors coregister for EE 260 (formerly EE 395) (or, if required, preregister for EE 261 and coregister for EE 262), and CompE majors coregister for EE 270 (formerly CS 395) (or, if required, preregister for EE 271 and coregister for EE 272). First offered Spring 1994. Students may use design projects as technical electives, without coregistration in EE 260 or 270.

### EE 203 Senior Design Project in Electronics 3

(*Partial Prerequisites:* EE 113; EE 200 (or 196)).

### EE 205 Senior Design Project in Power 3

(*Partial Prerequisites:* EE 180; EE 204)

### EE 207 Senior Design Project in Semiconductors and Materials 3

(*Prerequisites to be specified*)

### EE 209 Senior Design Project in Special Topics 3

(*Prerequisites to be specified*)

### EE 213 Senior Design Project in VLSI (Very Large-Scale Integrated Circuits) 3

(*Prerequisite:* EE 212, 113)

### EE 215 Senior Design Project in Control and Robotics 3

(*Partial Prerequisites:* EE 106 (or 104);

EE 200 (or 196)

### EE 217 Senior Design Project in Imaging 3

(*Partial prerequisite:* EL 512)

### EE 219 Senior Design Project in Electromagnetics and Waves 3

(*Partial Prerequisites:* EE 164 (or 166); EE 200 (or 196))

### EE 221 Senior Design Project in Electrical Engineering 3

(Catch-all; replaces EE 399 for EE's)

### EE 223 Senior Design Project in Computer Engineering 3

(Catch-all; replaces CS 398 for CompE's)

(*Partial prerequisites:* EE 297 (or CS 297))

### EE 225 Senior Design Project, Polytechnicmultisemester Plan 3

(Register in Final Semester)

### EE 227 Senior Design Project in Telecommunications 3

(*Prerequisites to be specified*)

### EE 229 Senior Design Project in Digital Signal Processing 3

(*Partial Prerequisites:* EE 105 (or 103), EE 140, EE 296 (or CS 296))

### EE 298 Senior Design Project in Computer Systems 3

(*Partial Prerequisites:* EE 297 (or CS 297))

### EE 260 Senior Electrical Engineering Project Planning and Presentation 1:1:0:1

For EE majors only. [Replaces EE 395 for EE majors effective Spring 1994]. If the Design Project should require advanced planning or purchases, this course may be split into:

#### EE 261 Senior EE Project Planning and Presentation I

1/2:1/2:0:1/2

Offered in the semester prior to the Design Project offering, and

#### EE 262 Senior EE Project Planning and Presentation II

1/2:1/2:0:1/2

Offered in the same semester as the Design Project.

**EE 270 Senior Computer Engineering Project Planning and Presentation** 1:1:0:1

For CompE majors only. [Replaces CS 395 for CompE majors effective Spring 1994.] If the Design Project should require advanced planning and purchases, this course should be split into:

**EE 271 Senior CompE Project Planning and Presentation I**

1/2:1/2:0:1/2

Offered in the semester prior to the Design Project offering, and

**EE 272 Senior CompE Project Planning and Presentation II**

1/2:1/2:0:1/2

Offered in the same semester as the Project offering.

**EE 371, 2, 3, 4, 5, 6 Guided Studies in EE**

1,2,3,4,5,6 credits respectively.

**EE 381, 2, 3, 4, 5, 6 Guided Studies in CompE**

1,2,3,4,5,6 credits respectively.

[Replace EE 398. Avoids need for documentation of "credits to be arranged".]

**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 oral reports and a formal bound report. An extensive design achievement is required. For students using this course as their Senior Project (along with EE 260 or 270), a professional written final report, corresponding to standards published by the Department, must be filed in the Department office for a passing grade. Formal oral presentation before a group of students and staff required. Brooklyn and Farmingdale; Fall and Spring; rarely Summer. Lab fee required. Prerequisite: Senior status and approval of Senior Faculty Department Adviser.

**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/graduate level
- 6 – first-year graduate level
- 7, 8 – advanced courses
- 9 – miscellaneous courses

Courses in selected topics bearing the same numbers may be repeated for credit provided the topics are different, subject to adviser's approval.

**LINEAR SYSTEMS AND NETWORKS****EL 613 Applied Matrix Theory** 2 1/2:0:0:3

In-depth introduction to theory and application of linear operators and matrices in finite-dimensional vector space. Invariant sub-spaces, 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 1/2:0:0:3

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, and EE 101 and EE 102.

**EL 617 System Reliability\*** 2 1/2:0:0:3

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: Graduate Status, EL 531 or MA 561 or equivalent. Also listed under IE 685

**SIGNAL PROCESSING****EL 512 Image Processing I** 2 1/2:0:0:3

Introduction of basic concepts and techniques in digital image processing: image acquisition and display using digital devices, properties of human visual perception, sampling and quantization, sampling rate conversion, two-dimensional transforms, linear and nonlinear filtering, morphological operations, contrast enhancement, noise removal, image deblurring, image registration and geometric transformation, edge detection. Students will learn to perform some basic image processing operations using computers equipped with special imaging hardware, such as video cameras and frame grabbers. Prerequisites: EE 103; MA 223; MA 153 or knowledge of basic matrix algebra; CS 212 or C-Programming skill; Senior or graduate student status. Instructor approval required for senior students.

**EL 611 Signals, Systems, and Transforms** 2 1/2:0:0:3

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 105.

**EL 612 Image Processing II**

2½:0:0:3

Advanced topics in digital image processing, such as image compression, image recovery, medical imaging, advanced television systems, etc. (See department mailing for detailed description of each particular offering.) Both basic principles and recent research developments will be introduced. In addition to the lecture material, each student is required to finish a term project implementing in software or hardware an existing or new image processing algorithm. *Prerequisites:* EL 512; EL 630; EL 610; C-Programming skill; Graduate student status.

**EL 711 Advanced Signals and Systems**

2½:0:0:3

Approximation methods in digital simulation of analog signals. Sampling theorems. Maximum system response under constraints. Analytic properties of Laplace transforms, complex inversion factorization, windows, extrapolation, maximum entropy. Two-dimensional and Hankel transforms. Diffraction. Fourier optics. Ambiguity functions and pulse compression. Spectral estimation. *Prerequisite:* Graduate Status or EL 611.

**EL 713 Digital Signal Processing I**

2½:0:0:3

Time and transform domain description of discrete-time signals and filters, Z-transforms, difference equations, discrete Fourier analysis and the FFT. Properties and design of recursive and non-recursive filters. Effects of finite precision arithmetic and round-off errors. Hardware realizations of digital filters. Introduction to spectral analysis. *Prerequisites:* Graduate Student Status and EL 611.

**EL 714 Digital Signal Processing II**

2½:0:0:3

Two-dimensional signals and systems: Fourier representations and multi-dimensional sampling. 2-d discrete Fourier transform and convolution. Difference equations, Z transforms and multi-dimensional stability. Design and implementation of non-recursive and recursive digital filters. Multiparameter statistical estimation theory: the principle of maxi-

imum likelihood. Signal parameter estimation in additive noise and performance degradation due to parameter uncertainty. The Kalman filter: Steady state theory and frequency domain analysis. Kalman filters for smoothing, correlated signal in noise and colored noise. *Prerequisites:* Graduate Student Status, EL 631 and EL 713.

**EL 715 Array Signal Processing**

2½:0:0:3

General sonar and radar array processing concepts. Array performance considerations. Narrowband and broadband signal processors. Classical and high resolution techniques for direction finding. Eigenstructure based techniques and spatial smoothing techniques. Performance analysis of eigen-structure-based techniques. Asymptotic distribution of eigenparameters associated with smoothed sample covariance matrices in uncorrelated and coherent scenes. Weiner solution and adaptive algorithms. Least Mean Square (LMS). Accelerated Gradient Search and Gradient algorithms with constraints. Direct implementation by inversion of the sample covariance matrix and transient response considerations. *Prerequisite:* Graduate Student Status, EL 611, EL 631.

**EL 911-919 Selected Topics in Systems**

each 2½:0:0:3

Selected topics of current interest in systems and networks. (See departmental mailing for detailed description of each particular offering). *Prerequisite:* Specified when offered.

*The following were formerly listed under Imaging Sciences and Engineering:*

**IM 606 Imaging Laboratory 0:5:0:3**

This laboratory is designed to give students physical contact with imaging techniques. Image formation is explored from matrix ray tracing to Fourier transform optics and holography. Polarized light in anisotropic materials and electro-optic effects are investigated, and one experiment in a major imaging technology (silver halide photography, electrophotography) is included. *Prerequisite:* Graduate Student Status, EL 551 or equivalent.

**IM 742 Introduction to Remote Sensing**

2½:0:0:3

Remote sensing is one of the important technological spin-offs of space exploration. This course presents an overview of the basic physics, the techniques, and the practical applications of remote sensing.

**CONTROL SYSTEMS****EL 522+ Sensor Based Robotics**

2½:0:0:3

Robot mechanisms, robot arm kinematics (direct and inverse kinematics), robot arm dynamics (Euler-Lagrange, Newton-Euler, and Hamiltonian Formulations), trajectory planning, sensing, end-effector mechanisms, force and moment analysis, introduction to control of robot manipulators. *Prerequisite:* Graduate Student Status. Concurrent with EE 106. Also listed under ME 661

**EL 621 System Theory and Feedback Control I**

2½:0:0:3

Design of single-input-output systems in the frequency domain. Stability of interconnected systems from component transfer functions. Parameterization of stabilizing controllers. Introduction to optimization (Wiener-Hopf design). *Prerequisite:* Graduate status and EE 106.

**EL 622 Nonlinear and Sampled-Data Control Systems**

2½:0:0:3

Introduction to nonlinear systems. Phase plane analysis, nonlinearities, linearization, limit cycles and averaging. Stability techniques: describing function, Lyapunov functions, Popov locus and circle criterion. Analysis and design of sampled-data systems by z-transforms and state variable methods. *Prerequisites:* Graduate Status, EL 610 and EE 106 or equivalent.

**EL 625 Linear System 2½:0:0:3 (\*Previously EL 610)**

Basic system concepts. Equations describing continuous and discrete-time linear systems. Time domain analysis, state variables, transition matrix, impulse response. Transform methods. Time—

## ELECTRICAL ENGINEERING

variable systems. Controllability, observability, and stability. *Prerequisite: Graduate status and EE 105. Also listed under ME 670*

### EL 721 System Theory and Feedback II 2½:0:0:3

A continuation of EL 621 for multi-input-output systems. Matrix fractions, optimal and suboptimal design considerations for two-degree of freedom systems. *Prerequisites: Graduate Status. EL 621 and EL 613.*

### EL 723 System Optimization Method 2½:0:0:3

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: Graduate Status. EL 610 or EL 613.*

### EL 724 H<sup>∞</sup> Frequency Domain Methods in Control 2½:0:0:3

Systems and operators, stabilizability, parameterization of stabilizing controllers, H<sup>∞</sup> weighted sensitivity minimization for rational plants, H<sup>2</sup> controller and H<sup>∞</sup> controller design. *Prerequisites: Graduate Status. EL 621 and EL 725. Also listed under ME 870*

### EL 725 State Space Design for Linear Control Systems 2½:0:0:3

Topics to be covered include: canonical forms; control system design objectives; feedback system design by pole placement; linear observers; the separation principle; linear quadratic optimum control; random processes; Kalman filters as optimum observers; the separation theorem; robust control; the servo compensator problem. *Prerequisite: Graduate Status. EL 625. Also listed under ME 671*

### EL 821 Analysis of Stochastic Systems\* 2½:0:0:3

Stochastic difference and differential equations. Wiener process and Markov systems. Kolmogorov's equations for

Markov systems. Stability of stochastic systems: stochastic Lyapunov functions, moment equations. *Prerequisite: Graduate Status. EL 631.*

### EL 822 Application of Nonlinear Control to Robotics 2½:0:0:3

Differential geometric approaches for control of nonlinear systems and applications to robot manipulators. Introduction to Lie algebra and Lie bracket. Multivariable inverses for nonlinear systems, external feedback linearization, zero dynamics. Application of nonlinear control to robotics: inverse dynamics, feedforward control, PD and PID controllers, variable-structure control, adaptive control techniques (STR and MRAC), and force control. *Prerequisite: Graduate Status. EL 725 (EL 522 is recommended but not essential). Also listed under ME 860*

### EL 823 Optimal Control Theory\* 2½:0:0:3

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: Graduate Status. EL 723 and EL 625. Also listed under MA 844 and ME 771*

### EL 825 Large Scale Systems and Decentralized Control 2½:0:0:3

Introduction to analysis and synthesis of large scale systems. System order reduction algorithms, interconnected system stability, series expansion and singular perturbation. Decentralized control: decentralized fixed modes, LQR, frequency shaped cost functionals, and overlapping decompositions. *Prerequisites: Graduate Status. EL 725 or instructor permission. Also listed under ME 873*

### EL 826 Adaptive Control 2½:0:0:3

Controllable and observable system models (ARMA models), parameter estimation (least squares, projection algorithm, lattice filters), one and multi-step ahead prediction control, minimum variance, pole placement, LQG control, model reference adaptive control.

*Prerequisite: Graduate Status. EL 725 or equivalent. Also listed under ME 871*

### EL 827 Stochastic Control 2½:0:0:3

Introduction to stochastic control, stochastic processes, covariance and spectral density, stochastic state models, spectral factorization of continuous or discrete time processes, parametric optimization, introduction to prediction and filtering theory: Wiener and Kalman filters. *Prerequisite: Graduate Status. EL 610 and EL 631. Also listed under ME 872*

### EL 921-929 Selected Topics in Control Engineeringeach 2½:0:0:3

Topics of current interest to feedback and control system engineers. (See department mailing for detailed description of each particular offering). *Prerequisite: Specified when offered.*

## INFORMATION SCIENCE

### EL 535 Elements of Communications Networks 2½:0:0:3

An introductory course in telecommunications networks. Review of calculus, and probability theory in the context of telecommunications. Modulation of sinusoidal waves. Amplification and regeneration. Characterization of telecommunications traffic in terms of spectrum, capacity, response, and duty cycle. Voice communications systems, switches, PBXs, and transmission options. Circuit switching. Facsimile, image, and video communications. ISDN and other integrated services approaches. *Prerequisite: Graduate status. This course cannot be applied towards degrees offered by the EE Dept.*

### EL 630 Probability 2½:0:0:3 (Previously EL 531)

Events, probability, repeated trials. Random variables distributions moments, characteristic functions. Functions of random variables. Sequences of random variables. Limit theorems. Engineering applications of statistics. *Prerequisite: Graduate status and MA 223.*

**EL 631 Engineering Applications of Stochastic Processes** 2½:0:0:3

Correlation, power spectrum, coherence, with applications in linear systems. Nonstationary signals, normal processes, mean square estimation, spectral analysis. Topics in Markov processes. *Prerequisite: Graduate Status. EL 630.*

**EL 632 Principles of Analog Communications** 2½:0:0:3

Performance analysis of AM and FM systems, FM bandwidth, Hilbert transform and its applications, noise models. Threshold effect in FM receivers and the application of phase locked loops to threshold extension. Sampling theorem, pulse modulation, A/D conversion pulse code modulation (PCM) and delta modulation, pulse design. *Prerequisite: Graduate Status. EE 140 or equivalent and MA 223 or equivalent.*

**EL 633 Detection and Estimation Theory** 2½:0:0:3

Detection of signals in noise, matched filters, M-ary digital communications. Signal detection and feature extraction in noisy environment based on likelihood ratio tests. Game-theoretic formulation of classification problems. Bayesian and point estimators: Near-optimum detectors. Combined estimation and detection. Wiener theory and Kalman-Bucy filters. *Co/Prerequisite: Graduate Status. EL 631.*

**EL 635 Principles of Communication Networks** 2½:0:0:3

An introductory course in data communications and computer communications networks. Many examples of networks, modeling. Basic principles of the design and performance analysis of networks. Data communication hardware: terminals, modems, multiplexers, concentrators, communications media. Nodal processor and host processor architecture. Software considerations and design. Protocols. Line control, polling and random access methods. Satellite and local area networks. *Prerequisite: Graduate status or EE 140.*

**EL 637 Local and Metropolitan Area Networks** 2½:0:0:3

Introduction. Local Area Networks: CSMA/CD, Token Ring, Token Bus: IEEE Standards, protocols and performance analysis. LAN interconnection: Bridges, Routers, Gateways. Metropolitan Area Networks: FDDI, FDDI II, DQDB: Standards and performance analysis. Higher Level Protocols used in LAN/MANs; LAN/MAN management, LAN/MAN interconnection: SMDS, Frame Relay, X.25, ISDN. Wireless Networks: Voice and data networks, emerging standards and protocols. Future Trends: B-ISDN, Gigabit Networks, High Speed LANs, lightweight protocols. Other current topics. *Prerequisites: Graduate Status. EL 635 or EE 392.*

**EL 733 Digital and Data Communications** 2½:0:0:3

Detection of signals in noise. Signaling through bandlimited channels: intersymbol interference, equalizers. Principles of M-ary communication: signal space methods, optimum detection. Bandwidth efficiency of modulation schemes, combined coding and modulation. Spread spectrum systems: bandwidth expansion schemes performance in jamming and multi-user environments. *Prerequisites: Graduate Status. EE 140 and EL 630.*

**EL 735 Communication Networks I** 2½:0:0:3

Analysis and modeling of centralized and distributed data communication networks. Modeling of user traffic, communications link and processors. Queueing analysis. Packet-switched network. Time delay analysis of networks. Capacity assignment. Concentration, multiplexing, polling, and buffer analysis. Multiple access for broadcast networks: satellites, ALOHA, ground radio, local area networks. New switching techniques. Integrated voice and data. *Prerequisites: Graduate Status. EL 630 and EL 635.*

**EL 736 Communication Networks II** 2½:0:0:3

Principles of network design, network design algorithms, centralized network design, static and dynamic routing algorithms, concentrator and switching node location, network reliability analysis, application of minimum spanning tree and shortest path algorithms to problems in network design, linear and integer programming techniques, distributed network design, case studies. *Prerequisites: Graduate Status. EL 635 and CS 603.*

**EL 737 Broadband Packet Switching** 2½:0:0:3

Introduction and overview of broadband networks, Circuit Switching, generalized circuit switching, Batchers sorting networks and generalizations: Batchers-banyan switches and contention resolution algorithm. Throughput and performance analyses of switches with inputs. Architecture and analyses of switches with output queues. Modular switches with mixed input and output queues. Deflection routing and error-correcting routing. Simulation technique for packet switches. Copy networks and multicast packet switching. Multiwavelength network and optoelectronic switching. DQDB and FDDI. *Prerequisites: Graduate Status. EL 735.*

**EL 738 Algebraic Codes\*** 2½:0:0:3

General theory of linear codes. Groups, rings, fields, matrices and vector spaces. Coding and error correction methods. Encoding and decoding cyclic codes. Convolutional codes and other encoding schemes. Capabilities and limitations of error-correcting code. Emphasizes codes used in computers. *Prerequisite: Graduate status and a basic knowledge of probability and linear algebra.*

# ELECTRICAL ENGINEERING

## EL 739 Information Theory\* 2½:0:0:3

Concepts of entropy and mutual information as mathematical measures for discrete information sources and discrete communications channels. Source encoding theorems and source coding techniques. Extension to sources with memory, channel capacity, and noisy channel coding theory. Extensions to continuous waveforms. *Prerequisite: Graduate Status. EL 630.*

## EL 833 Advanced Signal Processing\* 2½:0:0:3

Radon-Nikodym derivatives. Hajek-Feldman theorem for Gaussian stochastic processes. Detection and parameter estimation of stochastic and deterministic signals imbedded in colored and non-stationary Gaussian noise. Nonparametric methods in detection and estimation. Diversity reception systems. *Prerequisite: Graduate Status. EL 633.*

## EL 931-939 Selected Topics in Information Science each 2½:0:0:3

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 545† Microwave Integrated and Semiconductor Circuits-I 2½:0:0:3

Transmission line review; co-axial, two-wire, parallel plate transmission lines. Printed transmission lines: microstrip line, stripline and other printed lines; quasistatic analysis, introduction to spectral-domain analysis, Green's functions; characteristic impedance; attenuation, perturbation method. Coupled transmission lines, directional coupler, coupled line filters. Transmission line transitions: bends, junctions, cross-overs, qualitative equivalent models. *Prerequisite: Graduate Status. EE 164.*

### EL 546† Microwave Integrated and Semiconductor Circuits-II 2½:0:0:3

Review of semiconductor physics, introduction to microwave integrated circuits (MIC's) S-parameter analysis, flow graphs, stability criteria of amplifiers. Oscillators and amplifiers, noise figure, noise measurement. PN junction diodes, varactors, Schottley-barrier, PIN, IMPATT and Gunn diodes; bipolar and field-effect transistors; device physics and applications to VCO, frequency multipliers, detectors, mixers, attenuators, phase shifters, switches. *Prerequisite: Graduate Status. EL 545, EE 110.*

### EL 641 Advanced Electronic Circuitry I 2½:0:0:3

Basic semiconductor physics. Small-signal, low-frequency models for bipolar junction transistors and biasing. Physics, models, and biasing for field-effect transistors. General treatment of nonlinear controlled sources. High-frequency models. Single- and multi-stage broadband small-signal amplifiers, operational amplifiers, discrete and analog integrated circuits. *Prerequisite: Graduate status and EE 109 and EE 110.*

### EL 642 Advanced Electronic Circuitry II 2½:0:0:3

Tuned circuits and impedance transformers, narrow-band non-linear amplifiers. Tuned-circuit sine-wave oscillators, mixers, AM modulators and demodulators, and FM modulators and demodulators. *Prerequisite: Graduate Status. EL 641.*

### EL 643 Advanced Electronic Circuitry III 2½:0:0:3

Junction and field-effect transistors as switches. Basic digital logic gates and switching circuits. Integrated circuit logic schemes and "building blocks". Sweep circuits and switching circuits. *Prerequisite: Graduate Status. EL 641.*

### EL 645 Integrated Circuit (VLSI) System Design 2½:0:0:3

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. Com-

puter testing of logic functions and simulation of circuit functions. *Prerequisites: Graduate status, CS 337 and EE 113.*

### EL 646 Integrated Circuit (VLSI) Fabrication Techniques 2½:0:0:3

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 the 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, metalization, inter-connection, 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

See course listings under Power Engineering.

### EL 745 VLSI System and Architecture Design 2:2:0:3

This course is a continuation of EL 645 - Integrated Circuit (VLSI) System Design. This course provides background and hands-on experience for full-custom VLSI chip design, using CMOS (Complementary Metal Oxide Silicon) technologies. Physical designs of many subsystems, such as adders, multipliers, RAM, FIFO (First-In-First-Out), and PLA (Programmable Logic Arrays) are covered. Some regular VLSI Architectures, such as systolic array processors, suitable for some highly parallel computing and digital signal processing, are discussed. VLSI architectures for packet switching systems and high speed network protocols, that employ regularity at the chip and system level are the case studies presented in this class. Students finish and present a term project at the end of the semester. The project includes the design and simulation of a VLSI circuit/chip at mask level with available VLSI tools on SUN workstations. The topic of the project can be chosen by students or assigned by the instructor. Completed chip designs are sent out for fabrication. *Prerequisites: Graduate Status. EL 645 or permission of the instructor.*

**EL 941-949 Selected Topics in Electronics** each 2½:0:0:3

Special topics of current interest to staff in the field of electronic devices, circuits, and systems. (See departmental mailing for detailed description of each particular offering.) *Prerequisite: Specified when offered.*

**ELECTRO-OPTICS,  
QUANTUM ELECTRONICS  
AND MATERIALS SCIENCE****EL 551-552† Electro-Optics, I, II** each 2½:0:0:3

Maxwell equations; Propagation of plane waves: polarization, reflection, refraction, interfaces, and multilayers; diffraction; Fourier optics; Gaussian beams; Laser resonators; Optical fibers and Guiding layers; Optical waveguide couplers, Propagation in anisotropic media; Modulators, Optical detection. *EL 551 prerequisite: Graduate Status. EE 164 or equivalent. EL 552 prerequisite Graduate Status. EL 551.*

**EL 557† Introduction to Electric and Magnetic Properties of Solids** 2½:0:0:3

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: Graduate Status. EE 167.*

**EL 651 Statistical Mechanics I** 2½:0:0:3

Equilibrium distributions. Relationships to laws of thermodynamics. Quantum effects. Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein distributions. Applications to bulk properties of matter and to thermal radiation. Kinetic theory. Nonequilibrium phenomena using Boltzmann transport equation. *Prerequisite: Graduate status. Also listed under PH 663*

**EL 652 Statistical Mechanics II** 2½:0:0:3

Micro-, Macro-, and grand-canonical ensembles and principles of classical statistical mechanics. Condensation phe-

nomena. Treatment of fluctuation and transport phenomena. Density matrix formalism of quantum statistical mechanics. Many-body problems. *Prerequisite: Graduate Status. EL 651 or PH 663. Also listed under PH 664*

**EL 653-654 Quantum Electronics I, II** each 2½:0:0:3

Interaction of electromagnetic radiation with quantized matter systems; spontaneous emission, absorption and induced emission; Two-level systems; Relaxation processes; Homogeneous and inhomogeneous lines; Laser devices: Gaseous, solid state, and diode lasers; Laser dynamics: Q-switch, mode locked, and ultra short pulse generation; Non-linear optics: Harmonic generation, parametric interactions, Raman and Brillouin nonlinearities; Fundamental noise properties of laser oscillators. *EL 653 prerequisites: Graduate status. EE 167 or equivalent recommended. EL 654 prerequisite EL 653.*

**EL 655-656 Quantum Mechanics I, II** each 2½:0:0:3

Quantum mechanics with applications to atomic systems. The use of Schrodinger's equations. Angular momentum and spin. Problems and approximation methods. Semiclassical 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** 2½:0:0:3

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\*** 0:5:0:3

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 pro-

ject type designed to prepare students for independent research in above areas. Lab fee required. *Prerequisite: Graduate status.*

**EL 951-959 Selected Topics in Quantum Electronics, Material Science and Electro-Optics** each 2½:0:0:3

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\*** 2½:0:0:3

Motion of elementary charged particles in electromagnetic fields. Transformation laws for the electromagnetic field intensities. Magnetoplasma-dynamical equations. Electrical and mechanical power densities, 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: Graduate Status. EE 164*

**EL 568† Electric Drives I: Characteristics and Controls** 2½:0:0:3

Transient conditions in electric drives. Load torques, moments of inertia, masses and forces translated to a rotating shaft. Acceleration and deceleration time. Consideration in selecting motor power rating. Motor heating (cooling) under different kinds of duty. Load diagram construction. Speed control of electric drives. Four quadrant operation of dc and ac drives with static converter supply. Worked examples effectively illustrate the application of the mathematical derivations. *Prerequisite: Graduate Status. EE 180.*

**EL 569† Electric Drive II: Design\*** 2½:0:0:3

Torque-speed envelopes, electrical and mechanical ports. Modeling of the motor

## ELECTRICAL ENGINEERING

and speed control. Outline of direct approach to design. Mechanical and thermal stress limitations. Magnetic and electrical loading. Relations between flux and current densities. Determination of losses. Scaling laws. Flux plotting techniques. Procedures, computer programs, and applications. *Prerequisite: Graduate Status. EL 568.*

### EL 647 Power Electronics 2½:0:0:3

Principles of thyristor devices, GTOs, MOSFETs, dynamic characteristics of DC choppers, dependence of turnoff circuits on load characteristics, and switched-mode power supplies. Phase control, full wave circuits with inductive load, commutation. Power inverters. *Prerequisite: Graduate status and EE 105 (or 103), and EE 110.*

### EL 661 Introduction to Power System Engineering\* 2½:0:0:3

Power system engineering analysis: three-phase circuit calculations, network representations and load flow calculations. Reliability analysis: generation reliability. Generation costing and economic dispatch. *Prerequisite: Graduate Status. EE 183 or equivalent.*

### EL 662 Introduction to Power System Planning\* 2½:0:0:3

Power system economics: revenue requirements, load duration and reserve requirements. Load forecasting—econometric methods. Optimal expansion planning and methodologies: Optimal generation expansion computer modeling. Decision analysis techniques. *Prerequisite: Graduate Status. EL 661.*

### EL 663 Electrical Transients in Power Systems 2½:0:0:3

Analysis of lumped-circuit, normal and abnormal transients in power equipment and systems. Short-circuit fault analysis and transient recovery of three-phase circuits. Analysis of traveling-wave surges on transmission lines, windings, and on integrated systems. *Prerequisite: Graduate Status. EE 183 or equivalent.*

### EL 664 Relay Fault Protection\* 2½:0:0:3

Protective relay functions and classifica-

tion. Electromechanical relay types, operating principles, and basic characteristics. Communication channels for relaying. Current and voltage transformers, transducers. Protection of busses, transformers, generators, motors, and other station equipment by the zone protection method. Distribution and transmission line relaying systems. Relay setting calculations. Primary and backup protection, application, and philosophy with applied relay engineering examples. *Prerequisite: Graduate Status. EL 663.*

### EL 665 Power System Stability I\* 2½:0:0:3

Introduction to the study of power system dynamics: mathematical modeling of prime movers, power plants, synchronous machines, field exciters transmission lines, relay loads, and stabilizers. *Prerequisites: Graduate Status. EE 106 (or 104) and EE 183.*

### EL 666 Power System Stability II\* 2½:0:0:3

Study of electrical machine and system dynamics, system governing and generation control prime-mover, energy supply, system dynamics and control. *Prerequisite: Graduate Status. EL 665.*

### EL 961-969 Selected Topics in Power each 2½:0:0:3

Topics of current interest in electric power engineering. (See departmental mailing for detailed description of each particular offering.) *Prerequisite: To be specified when offered.*

## ELECTRODYNAMIC AND AVE PHENOMENA

### EL 571-572+ Engineering Electromagnetics I, II each 2½:0:0:3

Engineering applications of electromagnetics. A device-hardware 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, horn and dish antennas. Waveguide components: attenuators, phase shifters; waveguide-coaxial transitions, etc. Electromechanical transducers: loud

speakers, microphones, relays. *EL 571 prerequisite: Graduate Status. EE 164. EL 572 prerequisite: Graduate Status. EL 571.*

### EL 573+ Introduction to Microwave Engineering 2½:0:0:3

Review of EM theory, transmission lines. S, Z, Y, ABCD parameters, network theory, network analyzer, signal flow graphs. CAD methods. Impedance matching, multisection and tapered impedance transformer, Bode-Fano criteria. Power divider, directional coupler, hybrid circuits. Microwave resonators: series, parallel resonant circuits, stubs, and cavities. Filter theory and design: microstrip and stripline designs, coupled line filters, Kuroda identities, Chebyshev and maximally flat filters. *Prerequisite: Graduate Status. EE 164.*

### EL 581 Introduction to Plasma Engineering\* 2½:0:0:3

Basic plasma concepts and applications; parameters describing the plasma; motion of charged particles in electromagnetic fields; effect of particle collisions on plasma transport; diffusion and mobilities. Plasmas as dielectric media; plasma dielectric response functions for collective plasma oscillations and for electromagnetic wave propagation in plasma. *Prerequisite: Graduate Status. EE 164.*

### EL 671 Fields and Waves 2½:0:0:3

The course lays the groundwork to the theory and understanding of electromagnetic fields, their sources and their propagation in the form of waves. The treatment starts from basic physical concepts and develops the description of electromagnetic fields in terms of Maxwell's equations by using vector analysis and related techniques. *Prerequisites: Graduate status and EE 164.*

### EL 672 Electrodynamics: Wave Propagation and Guidance 2½:0:0:3

The electrodynamics of waves guided by metallic and dielectric structures, resonators, radiation, and other relevant theoretical aspects of modern electromagnetic engineering are covered. The emphasis is on understanding wave phe-

nomena and on studying the basic concepts and techniques that are useful when treating relevant problems over the entire electromagnetic spectrum. *Prerequisite: Graduate Status. EL 671.*

**EL 673 Electrodynamics: Fields and Materials** 2½:0:0:3

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 ferrites, waves in inhomogeneous media. *Prerequisite: Graduate Status. EL 671 or PH 623. Also listed under PH 625.*

**EL 676 Fundamentals of Radar\*** 2½:0:0:3

Principles of range and direction find 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: Graduate Status. EL 611.*

**EL 771-772 Radiation and Diffraction I, II\*** each 2½:0:0:3

First semester: An introductory level with asymptotic methods for radiation and diffraction. Saddle point approximations of radiation and diffraction integrals for harmonic and transient fields, wave packets; ray description of reflection and refraction, diffracted rays (geometrical theory of diffraction). Second semester: rigorous methods. Eigen-function expansions; discrete and continuous spectra. Green's functions; alternative representations, asymptotic reduction of rigorous integral representations. *EL 771 prerequisite: Graduate Status. EL 672. EL 772 prerequisite: Graduate Status. EL 771.*

**EL 773-774 Guided Waves and Beams I, II\*** each 2½:0:0:3

Theory and application of guided waves and beams in areas of electromagnetics (radar), microwave acoustics and integrated optics. Propagation characteristics of surface and leaky waves; effects of

loss; mode coupling; characterization of discontinuities. Propagation in periodic structures. Beam fields; properties of laser beams; divergence, Fresnel, and Fraunhofer approximations; scattering and guiding of beams by planar structures; beam displacement and distortion; coupling to surface waves. *EL 773 prerequisite: Graduate Status. EL 672. EL 774 prerequisite: Graduate Status. EL 773.*

**EL 775 Antenna Theory** 2½:0:0:3

Concepts of antenna radiation patterns, radiation resistance equivalent network; gain; effective area; reciprocity. Electromagnetic fields due to prescribed sources. Huygens' principle. Fresnel and Fraunhofer regions. finite and infinite arrays. Mutual coupling. Aperture antennas. Traveling-wave antennas. Frequency independent antennas. *Prerequisite: Graduate Status. EL 775.*

**EL 871 Advanced Ray Methods in Wave Propagation\*** 2½:0:0:3

Asymptotic theory of radiation and diffraction, with emphasis on inhomogeneous and dispersive media. WKB approximations and comparison methods, advanced saddle-point techniques and relation to ray optics. Space-time rays in inhomogeneous dispersive media, diffraction and transition phenomena for transients. *Prerequisite: Graduate Status. EL 772.*

**EL 873 Nonlinear Waves\*** 2½:0:0:3

Generic nonlinear wave equations. Whitham's Lagrangian formulation and averaging method. Quasi-particle techniques in nonlinear problems. Inverse scattering methods. Application of KdV, nonlinear parabolic, etc., equations in electrophysics. *Prerequisite: Graduate Status. EL 671.*

**EL 970 Microwave Engineering Laboratory/Project** 1:4:0:3

Design, fabrication, testing of passive circuits (couplers, filters), active circuits (amplifier, oscillator) and antennas using printed circuits. Design and simulation using microwave CAD tools (Supercompact, Touchtone, Puff, PCAAMT), HP-8510 automated Network Analyzer measurement, frequency and time-domain measurements, antenna pattern measurement, printed circuit layout and

photoetching. *Prerequisite: Graduate Status. EE164; Co-requisite: Graduate Status. EL 545 or EL 571.*

**EL 971-979 Selected Topics in Electromagnetic Theory** each 2½:0:0:3

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.*

**EL 981-989 Selected Topics in Plasmas** each 2½:0:0:3

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 591-599+ Selected Topics in Electrical Engineering** each 2½:0:0:3

Topics of current interest in electrical engineering offered for credit to both selected undergraduate and graduate students. (See departmental mailing for detailed description of each particular offering.) *Prerequisite: Specified when offered.*

**EL 891 Graduate Seminar\*** each 2½:0:0:3

Seminars in various areas of electrical engineering, electrophysics, system engineering, and computer science. Reports and discussions by staff members and students concerning recent developments in relevant areas. May be repeated for credit. *Prerequisite: Graduate status.*

**EL 990-991 Laboratory Internship I, II\*** each 0:5:0:3

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.*

## ELECTRICAL ENGINEERING

### EL 993-994 Readings in Electrical Engineering I, II *each 3 units*

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 0:5:0:3*

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 adviser. *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 cre-

ativity 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 Dean of School of Electrical Engineering and Computer Science  
B.S., University of Pennsylvania; M.S., Ph.D., Stanford University  
*Signal processing, reliability*

**Henry L. Bertoni**, Professor of Electrophysics and Head of the Department of Electrical Engineering  
B.S., Northwestern University; M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Electromagnetics; acoustics*

**Donald Bolle**, Professor of Electrical Engineering  
B.Sc., Durham University (England); Ph.D., Purdue University  
*Guided wave propagation, nonreciprocal devices*

**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*

**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. C Cassidy**, 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**, University Professor  
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn  
*Propagation and diffraction, optics*

**Ivan T. Frisch**, Provost, and Professor of Electrical Engineering and Computer Science  
B.S., Queens College; M.S., Ph.D., Columbia University  
*Information systems, computer networks and network control*

**Richard A. Haddad**, Professor of Electrical Engineering  
B.E.E., M.E.E., Ph.D., Polytechnic Institute of Brooklyn  
*Digital filters, power systems*

**Donald F. Hunt**, Professor of Electrical Engineering  
B.S., University of Pennsylvania  
*Networks and 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*

**Tony T. Lee**, Professor of Electrical Engineering  
B.S., National Cheng Kung University, Taiwan; M.S., Cleveland State

University; Ph.D., Polytechnic Institute of New York  
*Telecommunication switching and performance analysis*

**Richard Mandelbaum**, Professor of Mathematics; B.S., Rensselaer Polytechnic Institute; M.A., Ph.D., Princeton University  
*Networking protocol*

**Henry Ruston**, Professor of Electrical Engineering and Computer Science B.S.E.(Math), B.S.E.(EE), University of Michigan; M.S.(EE), Columbia University; Ph.D.(EE), U. Mich.  
*Software engineering, programming, circuit theory*

**Philip E. Sarachik**, Professor of Electrical Engineering A.B., B.S., M.S., Ph.D., Columbia University  
*Optimal and adaptive systems*

**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*

**Theodor Tamir**, University Professor 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 B.S., Stanford University; Ph.D., University of California (Berkeley)  
*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**, University Professor B.E.E., CCNY; M.S., New York University  
*Networks, control systems*

**Zivan Zabar**, Professor of Electrical Engineering B.Sc., M.Sc., Sc.D., Technion (Israel)  
*Power electronics, electric drives, power systems*

**H. Jonathan Chao**, Associate Professor of Electrical Engineering B.S., M.S., National Chiao-Tung University (Hsinchu, Taiwan); Ph.D., Ohio State University  
*Design of VLSI chips for telecommunications*

**Douglas A. Davids**, Associate Professor of Electrophysics B.S., M.S., Newark College of Engineering; Ph.D., Johns Hopkins University  
*Microwave acoustics, quantum electronics*

**I-Tau Lu**, Associate Professor of Electrical Engineering B.S. National Chiao-tung University (Taiwan); M.S. National Taiwan University; Ph.D. Polytechnic Institute of New York  
*Electromagnetics, microwave circuits*

**Shivendra S. Panwar**, Associate Professor of Electrical Engineering B. Tech., Indian Institute of Technology; M.S., Ph.D., University of Massachusetts  
*Communication networks*

**S. Unnikrishna Pillai**, Associate Professor of Electrical Engineering B. Tech., Indian Institute of Technology (Bombay); Ph.D., University of Pennsylvania  
*Signal processing*

**Peter Voltz**, Associate Professor of Electrical Engineering B.S., M.S., Ph.D., Polytechnic Institute of New York  
*Systems and control*

**Lawrence Carin**, Assistant Professor of Electrical Engineering B.S., M.S., Ph.D., University of Maryland  
*Computational electromagnetics, experimental optoelectronics*

**Nirod K. Das**, Assistant Professor of Electrical Engineering B. Tech., Indian Institute of Technology; M.S., Ph.D., University of Massachusetts  
*Electromagnetics, antennas*

**Giora Griffel**, Assistant Professor of Electrical Engineering B.S., Ph.D., Tel-Aviv University  
*Optoelectronic integrated circuits, semiconductor lasers*

**Farsbad Khorrami**, Assistant Professor of Electrical Engineering BSEE, B.S. (Math), M.S. (Math), Ph.D. (EE), Ohio State University  
*Robotics, control systems*

**Seung P. Kim**, Assistant Professor of Electrical Engineering B.S., Seoul National University; M.S.E.E., Korea Advanced Institute of Science and Technology; M.S. (Computer Engineering), University of Pittsburgh; Ph.D. (EE), Pennsylvania State University  
*VLSI signal processing*

**Leandros Tassiulas**, Assistant Professor of Electrical Engineering Diploma in Electrical Engineering, University of Thessaloniki, Greece; M.S., Ph.D., University of Maryland  
*Telecommunications scheduling and routing*

**Vassilis Tsotras**, Assistant Professor of Electrical Engineering and Computer Science B.S., National Technical University (Athens); M.S., Ph.D., Columbia University  
*Computer communication systems*

**Yao Wang**, Assistant Professor of Electrical Engineering B.S., M.S., Tsinghua University (Beijing); Ph.D., University of California at Santa Barbara  
*Image coding, pattern recognition*

## ASSOCIATED FACULTY

**Joel B. Snyder**, Senior Industry Professor of Electrical Engineering and Computer Science B.E.E., M.E.E., Polytechnic Institute of Brooklyn; P.E. (New York, Massachusetts)  
*Microprocessor systems, data acquisition and transmission, signal processing*

## ELECTRICAL ENGINEERING

**Shalom S. Bergstein**, Industry Professor of Electrical Engineering  
B.S., M.S., Ph.D., Polytechnic Institute of New York  
*Communications, fiber optics*

### ADJUNCT FACULTY

**X. K. Chen**, Adjunct Assistant Professor  
B.S., Hua Zhang University of Science and Technology (China);  
M.S., Ph.D., Polytechnic University

**Faut Agi**, Lecturer  
B.S., M.S., I.T.O. (Istanbul);  
P.E. (New York)

**John H. Chang**, Lecturer  
B.S., National Taiwan University;  
M.S., Ph.D., Yale University

**Frederick W. Freyre**, Lecturer  
B.S., City College of New York;  
M.S., Rensselaer Polytechnic Institute;  
Ph.D., Polytechnic Institute of New York

**Jalal Gohari**, Lecturer  
B.S., City College of New York

**Phillip Grieve**, Lecturer  
B.S., Cornell University;  
M.S., Ph.D., UCLA

**Howard Hausman**, Lecturer  
B.S., M.S., Polytechnic Institute of Brooklyn

**Robert Leahy**, Lecturer  
B.E.E., M.E.E., Polytechnic Institute of Brooklyn

**Gary Lomp**, Lecturer  
B.S., M.S., Polytechnic Institute of New York; Ph.D., Polytechnic University

**Muni Mitchell**, Lecturer  
B.S., M.S., University of Illinois;  
Ph.D.E.E., Polytechnic Institute of New York

**James Moulic**, Lecturer  
B.S., M.S., University of Illinois;  
Ph.D.E.E., Polytechnic Institute of New York

**Fred Winter**, Lecturer  
B.S. SUNY Stony Brook;  
M.S., Ph.D., Polytechnic University

### EMERITUS FACULTY

**Leo Birenbaum**, Associate Professor of Electrical Engineering and Electrophysics  
B.E.E. Cooper Union; M.E.E., M.S., Polytechnic Institute of Brooklyn

**Rudolf F. Drenick**, Professor Emeritus of Electrical Engineering  
Ph.D., University of Vienna (Austria)

**Herman Farber**, Associate Professor Emeritus of Electrophysics  
B.A., Brooklyn College;  
M.E.E., Polytechnic Institute of Brooklyn

**Anthony B. Giordano**, Professor Emeritus of Electrical Engineering and Dean Emeritus  
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn

**Alexander Hessel**, Professor Emeritus of Electrophysics  
M.Sc., Hebrew University; D.E.E., Polytechnic Institute of Brooklyn  
*Antenna theory*

**Enrico Levi**, Professor Emeritus of Electrophysics  
B.S. (M.E.), B.S. (E.E.), Dipl.Ing., Technion (Israel); M.E.E., D.E.E., Polytechnic Institute of Brooklyn

**Nathan Marcovitz**, University Professor Emeritus  
B.E.E., M.E.E., D.E.E., Polytechnic Institute of Brooklyn

**Eli Absalom Misbkin**, Professor Emeritus of Applied Physics  
Ingenlevr, Sc.D., Technion (Israel)

**Maurice C. Newstein**, Professor of Electrophysics  
A.B. Temple University; Ph.D., Massachusetts Institute of Technology

**Arthur A. Oliner**, Professor Emeritus of Electrophysics  
B.A., Brooklyn College; Ph.D., Cornell University

**Istvan Palocz**, Professor Emeritus of Electrical Engineering and Electrophysics  
Dip. E.E., Docent, University of Technical Sciences (Budapest); Ph.D., Polytechnic Institute of Brooklyn

**Athanasios Papoulis**, University Professor Emeritus  
M.E., E.E., Athens Polytechnic Institute (Greece); M.S., M.A., Ph.D., University of Pennsylvania

**Harry Schachter**, Professor of Electrical Engineering  
B.E.E., CCNY; M.S., Columbia University; Ph.D., Polytechnic Institute of Brooklyn

**Sidney S. Shamis**, Professor Emeritus of Electrical Engineering and Associate Provost  
B.E.E., Cooper Union;  
M.S., Stevens Institute of Technology

**Jerry Shmoys**, Professor Emeritus of Electrical Engineering  
B.E.E., Cooper Union;  
Ph.D. New York University

**Edward J. Smith**, Professor Emeritus 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 Emeritus of Electrical Engineering  
B.E. E., Cooper Union;  
S.M., Harvard University; D.E.E., Polytechnic Institute of Brooklyn;  
P.E. (New York)

# ELECTROPHYSICS

Polytechnic offers a program of study leading to the degrees of master of science and doctor of philosophy in electrophysics. The program is intended to prepare students to work at the interface between electrical engineering and physics, where new engineering applications of various physical phenomena are developed. Emphasis is placed on wave propagation and wave interactions with matter, as applied to a wide range of topics. Students entering the program typically have an undergraduate background in electrical engineering or in physics, a strong interest in physical phenomena and/or applied mathematics, and a desire to participate in research.

The program is administered by the Department of Electrical Engineering.

The program of study consists of basic courses in wave propagation, electromagnetic theory, and mathematical techniques offered through the Department of Electrical Engineering. In addition, a variety of more specialized courses at both the master's and doctor's levels are offered, covering technical areas where there is research and development activity on a world-wide basis. Traditional areas of active research that are covered include propagation and diffraction of waves, antennas, microwave networks, plasmas, and solid-state devices. Areas of modern optics that are covered include quantum electronics, lasers, and optical communications. Additional areas are non-linear wave propagation, ultrasonic waves in solids, 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 laboratories devoted to surface acoustic waves, magnetostatic wave devices, lasers, semiconductors, ion implantation, microwaves and millimeter waves, gas discharges and plasmas. The Brooklyn campus has laboratories devoted to electro-optics and ultrasonics.

## 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 point 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. Course Courses

Three courses from among the following:

EL 551	<i>Electro-Optics I</i>
EL 581	<i>Introduction to Plasma Engineering</i>
EL 611	<i>Signals, Systems and Transforms</i>
EL 651	<i>Statistical Mechanics I</i>
EL 653	<i>Quantum Electronics I</i>
EL 671	<i>Fields and Waves</i>

9 Units

- 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

- 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 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 EE Department Graduate Student Manual should be consulted for more detailed rules and procedures, including student status, recommended electives and one-year sequences, current areas of research, and disqualification for low grades.

## REQUIREMENTS FOR THE DOCTOR'S DEGREE

Graduate students who have demonstrated a high degree of scholastic proficiency and have given evidence of ability 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

## ELECTROPHYSICS

the EE 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 electronics, solid-state electronics, electromagnetics, and electro-optics. Current information about examination topics should be obtained from the Electrical Engineering graduate office.

### GRADUATE

#### **EP 997 Thesis for Degree of Master of Science in Electrophysics**

*each 3 units*

Independent research project demonstrating professional maturity, performed under guidance of adviser. Oral thesis defense and formal bound thesis volume required. Registration of 9 units required (continuous thesis registration required). *Prerequisite: Degree 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 the 12th unit requires passing of area examination.*

### PARTICIPATING FACULTY

**Leonard Bergstein**, Professor of Electro-Optical Sciences

**Henry L. Bertoni**, Professor of Electrophysics

**Lawrence Carin**, Assistant Professor of Electrophysics

**Nirod Das**, Assistant Professor of Electrical Engineering

**Bernard R.S. Cheo**, Professor of Electrical Engineering

**Leopold B. Felsen**, University Professor

**Giora Griffel**, Assistant Professor of Electrical Engineering

**Erich E. Kunhardt**, Ernst Weber Professor of Electrophysics

**Szu-Ping Kuo**, Professor of Electrical Engineering and Electrophysics

**Theodor Tamir**, University Professor

**Wen-Chung Wang**, Professor of Electrical Engineering and Electrophysics

**Douglas A. Davids**, Associate Professor of Electrophysics

**I-Tai Lu**, Associate Professor of Electrical Engineering

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

The Department of Civil and Environmental Engineering offers undergraduate and graduate programs in environmental engineering and environmental health science leading to the following degrees with environmental designation:

- Bachelor of Science in Environmental Engineering
- Master of Science in Environmental Engineering
- Master of Science in Environmental Health Science
- Doctor of Philosophy in Environmental Health Science

The Department also offers the following graduate programs with environmental engineering majors, but with civil engineering designation:

- Master of Science in Civil Engineering
- Engineer in Civil Engineering
- Doctor of Philosophy in Civil Engineering

**Programs with environmental engineering and environmental health science designations are described below. Programs with civil engineering designations are described in the section of this catalog for Civil Engineering.**

The environmental field has grown to include widespread participation of engineers, health science professionals, scientists, architects, planners, economists, and social scientists. The diversity of challenges in this field involve capabilities to deal with rapidly expanding knowledge bases, a need to react to changing environmental criteria, and highly interdisciplinary teams that work collaboratively. Society's sensitivity to the environment has grown strong over the last several decades and has influenced virtually every profession in the country. In this context today, environmental engineering and environmental health science are broad fields that deal

not only with the transformations of mass and energy in the environment as a result of human or natural activities, but also with issues of how societies perceive and respond to this process of change.

The programs offered by the Department are professional degrees in the first two disciplines mentioned above - i.e. engineering and its closely allied field of health science - that emphasize environmental engineering and science applications.

Graduates with degrees offered by the Department are employed by governmental environmental regulatory and construction agencies; consulting firms that specialize in environmental engineering and planning; industrial firms whose factories or products have an impact on the air, water or land environments; and engineering, testing and control laboratories that are engaged in research and monitoring of environmental problems. These degrees may also be attractive to science teachers who wish to broaden the scope of the courses they teach.

The program for the Bachelor of Science in Environmental Engineering degree involves a multi-faceted approach of environmental science, engineering, planning, and management. It draws on the strengths of the Department in environmental engineering, water resources engineering and management, geotechnical and geo-environmental engineering, and project management and construction engineering.

Graduate programs in environmental engineering and environmental health science are suitable for students having undergraduate degrees in the physical, chemical or biological sciences, or any engineering field. Most courses in these programs are attended by both health science and engineering students, and the course materials and faculty are highly interdisciplinary, corresponding to the practice of these environmental professions.

Requirements for the Master's degree include prescribed courses and approved elective courses. A project must be completed. A thesis may be substituted for project and elective courses.

The Ph.D. degree requires advanced study beyond the master's level and high level original work. A thesis must be written and defended.

Computer literacy is a requirement for all areas of specialization. In some cases, an undergraduate or graduate course may be included in the program to overcome deficiencies.

Students interested in graduate programs are advised to refer to the Graduate Student Manual (available from the office of the Department of Civil and Environmental Engineering) for further information on degree requirements and the latest revisions of curricula and courses.

## UNDERGRADUATE PROGRAM

The undergraduate program leading to the Bachelor of Science in Environmental Engineering has been approved by the New York State Education Department.

The fundamental sciences of mathematics, physics and chemistry are presented first, together with principles of computer programming. The relevance of these subjects to engineering is shown in two introductory courses in engineering which include examples of knowledge and applications in various engineering fields and provide hands-on laboratory and design experiences.

The basic engineering sciences for civil and environmental engineering are presented next and include engineering measurements, and properties of materials such as steel and concrete, soils, and

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

fluids. This phase also includes courses in ecology and organic and physical chemistry which are a foundation for the environmental engineering courses that follow.

The last phase of the program provides courses with specific professional applications in the planning, analysis, design, and construction of projects. For environmental engineering, these include facilities for water supply and wastewater treatment, air pollution control, disposal of solid and hazardous wastes, and other environmental control and protection projects.

Written and verbal skills are developed in introductory English courses and in required exercises in many technical courses. Intellectual horizons are extended through courses in the humanities and social sciences.

The program prepares students broadly in all major areas of environmental engineering so that graduates can be immediately employed in the profession.

The program also provides the basis for proceeding directly to graduate degree programs in environmental engineering, or to professional degree programs in law, management, and medicine.

## TECHNICAL ELECTIVES

To allow students to broaden their technical knowledge, the curriculum provides 6 technical elective credits of appropriate coursework. Approved technical electives are indicated below, including graduate courses that are suitable for undergraduate students. Senior courses in civil engineering and in other departments, and other graduate courses may be chosen, but they require the approval of a departmental adviser.

IE 300	<i>Engineering Economy</i>
CE 353	<i>CAD in Civil Engineering</i>
CE 849	<i>Environmental Geotechnology</i>
CE 758f	<i>Air Pollution Engineering Control</i>
CH 752	
CE 726	<i>Computer Applications in Water Resources</i>
CE 825	<i>Project Management for Construction</i>

ROTC students should note that 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 and environmental engineering undergraduate adviser according to university and departmental guidelines.

For further information, students should refer to the section of this catalog entitled "Humanities and Social Sciences Requirements for Engineering and Computer Science Majors".

## TRANSFER STUDENTS (Undergraduate)

Potential transfer students should refer to the University guidelines as shown elsewhere in 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 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:

- the number of transfer credits awarded
- the particular courses required to complete the degree requirements
- 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 29 credits at Polytechnic with a civil and environmental engineering designation as indicated below:

Junior Year	Senior Year
<i>1st Term</i>	<i>1st Term</i>
CE 340	CE 318
CE 341	CE 343
	CE 346
	CE 347
<i>2nd Term</i>	<i>2nd Term</i>
CE 232	CE 344
CE 342	CE 348

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 academic years, with appropriate summer school coursework for one or two summers, depending on their preparation.

Transfer students who have completed the first two years of a bachelor's degree in civil engineering can normally expect to complete the bachelor's degree requirements in environmental engineering within two academic years, with appropriate summer school coursework immediately preceding the junior year.

Students from 2-year and 4-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.

## PART-TIME STUDENTS (Undergraduate)

Prospective students planning to earn a degree on a part-time basis should contact an undergraduate adviser for details about this plan before enrolling. Most upper-level courses that are common to the civil and environmental engineering degree programs are offered on an alternate-year basis and may be integrated with the day program using a late afternoon schedule starting at 4 pm. Such scheduling is not normally available for other courses in the environmental engineering program.

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

## Typical Course of Study for the Bachelor of Science Degree in Environmental Engineering

### FRESHMAN YEAR

No.	Subject	Hours / Week		
		Cl.	Lab.	Cr.
<b>Fall</b>				
MA 106	Calculus I(1)	5	0	4.0
CM 101	Gen. Chem. I	3	0	2.5
CM 111	Gen. Chem Lab I	0	1.5	0.5
CS 200	Program Method.	4	0	3.0
HU 101/3	Writing & Hum. I(1)	3	0	3.0
EG 101	Intro to Eng.	2	3	3.0
SL 101	Freshman Seminar	1	1	0.0
	<b>Subtotal</b>			<b>16</b>

### Spring

MA 107	Calculus II	5	0	4.0
CM 102	Gen. Chem II	3	0	2.5
CM 112	Gen. Chem Lab II	0	1.5	0.5
PH 107	Mechanics	4	0	3.0
HU 200	Writing and Hum. II or			
SS 104	Contemporary World			
	History (2,3)	3	0	3.0
CS 100	Intro. to Eng. Design	2	3	3.0
	<b>Subtotal</b>			<b>16</b>

### SOPHOMORE YEAR

#### Fall

MA 108	Differential Equations & Num Methods	3	0	3.0
PH 108	Electr. Magnetism, & Fluids	4	0	3.0
PH 118	Phys. Lab for PH108	0	1.5	0.5
HU 200	Writing & Humanities II or			
SS 104	Contemporary World			
	History (2,3)	3	0	3.0
CE 153	Meas. in Civ. Eng.	1.5	1.5	2.0
ME 111	Eng. Mechanics I	3	0	3.0
CE 160	Ecology for Env. Engr & Scists	3	0	3.0
	<b>Subtotal</b>			<b>17.5</b>

#### Spring

MA 109	Multidem Calculus	4	0	3.0
PH 109	Waves, Optics & Thermo	4	0	3.0
PH 119	Phys. Lab for PH109	0	1.5	0.5
HU/SS	Hum/Soc. Sci. Elect.	3	0	3.0
HU 110	Prof. Report Writ.	3	0	3.0
CE 223	Fluid Mechanics	2.5	1.5	3.0
CM 161	Physical Chemistry I	3	0	3.0
	<b>Subtotal</b>			<b>18.5</b>

### JUNIOR YEAR

No.	Subject	Hours / Week		
		Cl.	Lab.	Cr.
<b>Fall</b>				
HU/SS	Hum/Soc. Sci. Elect.	3	0	3.0
MA 222	Intro to Probab & Statistics	3	0	3.0
CE 307	Const. Materials	2	3	3.0
CE 340	Water Resources & Hydraulic Eng.	3	0	3.0
CE 341	Environmental Eng I	2	3	3.0
CM 122	Organic Chemistry	3	0	3.0
	<b>Subtotal</b>			<b>18</b>

### Spring

HU/SS	Hum/Soc. Sci. Elect.	3	0	3.0
CE 232	Soil Mechanics	2	3	3.0
CE 202	Mech. of Materials	3	0	3.0
CE 342	Env. Eng. II	2	3	3.0
CH 250	Chemical Eng. Thermodynamics I	3	0	3.0
CH 222	Mass Transfer Oper.	3	0	3.0
	<b>Subtotal</b>			<b>18</b>

### SENIOR YEAR

#### Fall

HU/SS	Hum/Soc. Sci. Elect.	3	0	3.0
CE 318	Physico-Chemical Soil Properties	2	3	3.0
CE 343	Solid & Haz. Wastes	3	0	3.0
CE 346	Hydrogeology	3	0	3.0
CE 347	Air Pollution	3	0	2.0
	Technical Elective			3.0
	<b>Subtotal</b>			<b>17</b>

#### Spring

HU/SS	Hum/Soc. Sci. Elect.	3	0	3.0
CE 335	Proj Mgmt for Const.	3	0	3.0
CE 344	Env Eng Project (4)	2	3	3.0
CE 348	Anal. of Public Works	3	0	3.0
	Technical Elective			3.0
	<b>Subtotal</b>			<b>15</b>

Total 136 (5)

#### Notes:

- (1) Placement by examination
- (2) Students taking HU 200 in Freshman second semester take SS 104 Sophomore first semester & vice versa
- (3) ESL students must take HU 103 before taking SS 104
- (4) Additional Senior Design Project credits are included in CE 343 and CE 347
- (5) Minimum total credits required for graduation 136 with a minimum GPA of 2.0

## REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

Two programs in the environmental field are offered, in addition to the M.S. in civil engineering. Students pursuing the M.S. in environmental health science or the M.S. in environmental engineering generally have undergraduate or graduate preparation in the sciences, although the M.S. in environmental engineering may also be taken by students with engineering preparation.

Courses in some areas of specialization are not offered on a regular basis. Students should consult with the department advisers to determine the expected scheduling of such courses.

A program is under development in hazardous materials management, comprising courses in toxicology, environmental law, and site remediation technologies. When available, these courses may be selected as electives in the MS programs in civil engineering, environmental health science, and environmental engineering.

### M.S. PROGRAM IN ENVIRONMENTAL HEALTH SCIENCE

#### Departmental Requirement

	Units
CE 996 Project for the Degree of Master of Science	3
	<b>3</b>

#### Environmental Health Science Requirements

CE 737 Environmental Chemistry & Microb. I	3
CE 739 Environmental Chemistry & Microb. II	3
CE 742 Water & Wastewater Treatment I	3
CE 743 Water & Wastewater Treatment II	3
CE 751 Environmental Health Engineering	3
CE 752 Air Pollution	3
CE 770 Solid Waste Management	3
	<b>21</b>

#### Approved Electives

At least 12 units of approved graduate courses	12
Minimum Total Units	36

**M.S. PROGRAM IN ENVIRONMENTAL ENGINEERING**

**Departmental Requirement**

CE 996	<i>Project for the Degree of Master of Science</i>	Units 3
--------	--	------------

**Environmental Engineering Graduate Course Requirements**

CE 715	<i>Open Channel Hydraulics</i>	3
CE 722	<i>Hydrology</i>	3
CE 737	<i>Environmental Chemistry &amp; Microb. I</i>	3
CE 739	<i>Environmental Chemistry &amp; Microb. II</i>	3
CE 742	<i>Water &amp; Wastewater Treatment I</i>	3
CE 743	<i>Water &amp; Wastewater Treatment II</i>	3
CE 747	<i>Analysis of Stream &amp; Estuary Pollution</i>	3
		21

**Approved Graduate Electives**

<i>At least 12 units of approved graduate courses</i>	<u>12</u>
<i>Minimum Total Units Graduate Studies</i>	36

**Required Additional Undergraduate Work for the MS in Environmental Engineering** - Minimum background in science should include one year each of chemistry and physics and, in mathematics should include basic courses in calculus and differential equations. In addition, a minimum of 15 credits of additional undergraduate makeup or prerequisite courses are required. Transfer credit for undergraduate courses and for non-engineering graduate courses from other institutions will not normally be allowed. Individual programs will depend on the previous preparation of the student, and may be approved by a Department Committee. Students with a Bachelor's degree in engineering may have the requirements partially or fully waived.

**REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE**

Students with exceptional scholastic ability may pursue a doctorate in civil engineering or environmental health science. An applicant for a doctorate in civil engineering must hold a master's

degree in civil engineering. For a doctorate in environmental health science, a master's degree in science is a prerequisite. Applicants with degrees in other fields may be admitted with deficiencies as evaluated by a departmental graduate adviser and upon approval of the department head.

All doctoral students must complete a minimum of 90 units of work beyond the bachelor's degree. Minimum requirements of formal course work (not including guided readings, seminars, projects and theses) are 48 units beyond the bachelor's degree or 24 units beyond the master's degree. Generally, at least 12 units of formal coursework must be completed at Polytechnic. Ph.D. students must select a major field and two minor fields in consultation with the advisers. Each minor consists of 9 to 15 units of approved courses.

To qualify as Ph.D. candidates, students must pass a written and oral qualifying examination on the major and one minor. The oral examination may be waived in exceptional cases by the department head upon the recommendation of the examining committee. Generally, students take the qualifying examination within their first year of full time course work beyond the M.S. degree. Students are allowed a maximum of 3 attempts to pass the qualifying examination.

Students must submit and orally defend dissertation proposals within one semester after the initial registration for dissertation units or before going beyond 9 dissertation units.

Registration for a minimum of 30 units of dissertation research is required. Registration should be continuous, until the dissertation has been completed and accepted.

**UNDERGRADUATE COURSES**

**CE 153 Measurements in Civil Engineering** 1 1/2:1 1/2:2

Overview of surveying and mapping. Fundamental techniques in distance measuring, leveling, angle and direction measurements. Cross section leveling. Errors and corrections. Area and volume

calculations. Traverse and route surveys. Curve location and layout. Topographic and mapping surveys. Photogrammetry, GIS and remote sensing. Applications of surveying: leveling and road layout; land, boundary and control surveys. Reports and other presentations based on laboratory experimentation.

**CE 160 Ecology for Environmental Engineers and Scientists** 3:0:3

This course will cover areas relating to environmental engineering and science. Such topics will include limnology; fresh water, marine and estuarine ecology; terrestrial ecology; species preservation; ecosystem revitalization; ecotoxicology; preserving biodiversity; global climate effect, and environmental impact analysis.

**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: ME 111.*

**CE 223 Fluid Mechanics** 2 1/2:1 1/2:3

Fluid properties. Hydrostatics. Continuity, energy and momentum equations. Laminar and turbulent flow. Similitude and dimensional analysis. Incompressible flow in closed pipes. Laboratory work parallels and supplements lectures. *Prerequisite: ME 111*

**CE 232 Soil Mechanics I** 2:3:3

Geological soil-forming processes and physical and mechanical properties of soils. Plasticity, capillarity, permeability, stress distribution in soil masses, consolidation theory, settlement of structures. Laboratory studies of physical and mechanical properties of soils. *Prerequisites: CE 223 and CE 202.*

**CE 307 Construction Materials** 2:3:2

Material properties and behavior. Environmental impact and concerns. Structure, physical and mechanical properties of construction materials such as: timber, aggregates, asphalt, concrete, metals and alloys, plastics, masonry and mor-

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

tar. Relationship between microstructure and behavior. Asphalt and concrete mixture design, performance and deterioration. Plastics and geosynthetics. Reclaimed materials and recycling of waste products in civil engineering applications. Materials related to environmental hazards. Experimental investigation of mechanical and physical properties of selected construction materials.

## **CE 318 Physico-Chemical Soil Properties** 2:3:3

Geological soil formation processes, soil mineralogy, clay-water-electrolyte system, soil composition and engineering behavior, flow phenomena through soil, contaminant transport phenomena, geo-environmental applications. *Prerequisites: CE 223, CE 202, CM 102, CE 232.*

## **CE 335 Project Management for Construction** 3:0:3

The participants, processes and techniques required to maintain the life cycle of a construction project. Planning of construction operations, including cost estimating and economic evaluation of alternatives. Analysis of the construction bid process, contracting, and related issues on ethics in project engineering. Productivity, safety and quality on the constructed project. Time scheduling of the project, including CPM and PERT. Trends in computer analysis of project information. *Prerequisite: Senior Status.*

## **CE 340 Water Resources and Hydraulic Engineering** 3:0:3

Fluid Measurements. Hydrologic techniques. Surface water and ground water supplies. Open channel flow. Water transmission and distribution. Wastewater and storm water drainage. Development of water resources projects. *Prerequisite: CE 223.*

## **CE 341 Environmental Engineering I** 2:3:3

Water and wastewater quantities. Water quality. Water and wastewater treatment, stream assimilation, public health and environmental problems. Laboratory analyses of water and wastewater samples, treatment process tests. *Prerequisites: CE 223 and CE 340.*

## **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 340 and CE 341.*

## **CE 343 Solid and Hazardous Wastes** 3:0:3

Study of the processes involved in solid waste management from generation and collection to disposal by landfilling, recycling and incineration. Study of factors involved in hazardous material management including regulations, laws, classification, storage, collection, transport, risk assessment, health and safety, site remediation and prevention.

## **CE 344 Environmental Engineering Project** 2:3:3

Comprehensive design of an environmental engineering project integrating project planning, process design, engineering design and specifications, construction costs and scheduling activities including a final project and final oral presentation. Examples of projects will include solid waste collection, transportation and disposal such as land fill design and site remediation of hazardous waste sites incorporating various aspects of remedial investigation, feasibility studies, ground water treatment, bioremediation and physical-chemical treatment. Lectures, seminars, group discussions simulating multi-disciplinary design experiences. *Prerequisites: CE 342, CE 343*

## **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 223.*

## **CE 346 Hydrogeology** 3:0:3

Descriptive geology with emphasis on the occurrence and movement of groundwater. Properties of natural groundwater, geochemistry. Characteristics of confined and unconfined

flow. Well hydraulics. Groundwater pollution and contaminant transport. Elementary groundwater modeling concepts. Groundwater and geologic processes. *Prerequisite: CE 340*

## **CE 347 Air Pollution** 2:0:2

Causes and effects of air pollution. Methods of sampling. Interpretation of data. Meteorological aspects. Methods of air pollution control.

## **CE 348 Analysis of Public Works** 3:0:3

Methods for the identification, formulation, preliminary appraisal, and detailed analysis of individual projects and systems of civil and environmental 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 analyses. Mathematical models for evaluation of alternatives and optimization. Impacts of projects: environmental, social, regional economic growth, legal and institutional, and public involvement. Tutorial/problem periods will focus on environmental laws, public participation process, and preparation of environmental impact assessments.

## **CE 353 CAD in Civil Engineering** 2:3:3

Thorough exposure to architectural CAD in civil engineering design. Fundamentals of CAD, its uses, and types of CAD equipment and software. Principles of transformations, geometric modelling and drafting. Interactive computer graphics, 3-D modelling, and effect of color. Application of CAD to engineering analysis. Incorporation of CAD in project data management. Laboratory assignments to reflect coursework. *Prerequisites: EG 102, CS200 and Senior status.*

## **CE 391-392 Bachelor's Thesis in Civil or Environmental 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 register for thesis until completed. Prerequisite: Senior status.

**CE 396 Civil or Environmental Engineering Internship** 2:0:2

Supervised, creative civil or environmental 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 visitations 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 or Environmental Engineering**  
2 or 3 credits as arranged

Solution to civil or environmental engineering problem or detailed study of an advanced area of civil or environmental 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**

**UNCLASSIFIED**

**CE 598-599 Special Topics in Civil or Environmental Engineering** 2½:0:3

Specialized current topics of interest of an interdisciplinary nature. Offered at irregular intervals. Advance announcements include course description and prerequisites.

**CE 780 Analysis of Uncertainty in Civil Engineering** 2½:0:3

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.

**CE 781 Analysis of Public Works** 2½:0:3

Methods for the identification, formulation, preliminary appraisal, and detailed analysis of individual projects and systems of civil and environmental 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. **Also listed under MG 830.**

**CE 790 Fire Protection Engineering** 2½:0:3

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. Mea-

sures for fire protection: detection, alarm and communication systems and systems for fire suppression and smoke control.

**CE 791 Infrastructure Systems Analysis** 2½:0:3

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 215 or equivalent.*

**ENVIRONMENTAL ENGINEERING**

**CE 737 Environmental Chemistry and Microbiology I** 1:2:3

Introduction to the chemistry and microbiology of polluted and natural waters, including applications of principles developed.

**CE 739 Environmental Chemistry and Microbiology II** 1:2:3

Advanced topics in chemistry and microbiology of polluted and natural wastewater treatment.

**CE 742 Water and Wastewater Treatment I** 2½:0:3

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 737.*

**CE 743 Water and Wastewater Treatment II** 2½:0:3

Continuation of CE 742. Topics include sedimentation, adsorption, aerobic and anaerobic biological treatment, sludge treatment and disposal. *Co-Prerequisite: CE 739.*

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

## **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

Causes and effects of air pollution. Methods of sampling. Interpretation of data. Meteorological aspects. Methods of air pollution control.

## **CE 753 Hazardous/Toxic Waste Management** 2 1/2:0:3

Methods in the management of hazardous/toxic waste sites. Topics covered include health and safety, legal aspects, contamination of the environment, treatment processes, toxicology and risk assessment.

## **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: Approval of Adviser. 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 evaluations. 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 are 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 reutilization, 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 nitrification in natural and treated waters, hazardous and toxic wastes, organic removal from water supplies, water reuse, specialized aspects of biological wastewater treatment, environmental health, solids disposal, and modeling natural waters and treatment systems. *Prerequisite: permission of the instructor.*

## **WATER RESOURCES ENGINEERING**

*Prerequisite for all courses: MA 108, CE 223*

## **CE 712 Water Resources Projects** 2 1/2:0:3

Feasibility-level planning and design studies for water resources projects, including water conveyance works; concrete dams and associated waterways; pumping stations; hydroelectric, irrigation, navigation, and flood mitigation projects. Subjects considered include layouts, dimensions and capacity of facilities, hydraulic and structural forces, and stability analyses. *Co-Prerequisite: CE 340 or CE 715, or approval of Adviser.*

## **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 716 Applied Hydraulics** 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 340 or CE 715.*

## **CE 722 Hydrology** 2 1/2:0:3

Hydrologic cycle. Meteorological considerations. Analyses of precipitation, runoff, unit hydrographs, flood routing and reservoir storage. Principles of groundwater hydrology. Introduction to frequency analysis of floods and droughts. *Prerequisite: Approval of Adviser.*

## **CE 723 Groundwater Hydrology and Pollution** 2 1/2:0:3

Characteristics of confined and unconfined flow of water through porous media, groundwater and well hydraulics; quality of ground water; environmental influences; groundwater pollution; management aspects of groundwater; and groundwater modeling. *Prerequisite: CE 340 or approval of Adviser.*

# ENVIRONMENTAL ENGINEERING AND ENVIRONMENTAL HEALTH SCIENCE

## **CE 724 Advanced Groundwater Hydrology and Pollution** 2½:0:3

Mass and heat transport in porous media. Unsaturated flow and transport. Numerical solutions of governing equations. Stochastic analysis. Groundwater quality monitoring and simulation. Dispersive mixing, decay, adsorption, retardation, soil microbiology. Soil and groundwater monitoring. Control of subsurface pollution; treatment technologies. Case studies. *Prerequisite* CE 723 or equivalent.

## **CE 725 Water Resources Mathematical Modeling** 2½:0:3

Studies of hydraulic, hydrologic, water quality and systems models as applied to rivers and streams, embankments, 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: Course in computer programming and Co-Prerequisite: CE 715.*

## **CE 726 Computer Applications in Water Resources** 2½:0:3

Applications of commercial software in water resources planning and design. Class meets in a computer classroom and hands-on experience is offered. Examples include analysis of flood hydrographs, open channel flow, river hydraulics, pipe networks, watershed hydrology, storm water management, and groundwater flow and transport. *Prerequisite* CE 340.

## **CE 728 Optimization Methods in Water Resources** 2½:0:3

Advanced theory of mathematical programming and optimal control with applications in planning and operation of water resource systems. *Prerequisite: CE 722 or equivalent.*

## **CE 735-736 Special Topics in Water Resources and Hydraulic Engineering I, II** 2½:0:3

Topics in water resources and hydraulic engineering such as hydroeconomic models; finite difference and finite element models; synthetic hydrology; conjunctive use of surface water and ground water; desalinized and recycled water; thermohydrologic and hydrometeorological 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.*

## **CONSTRUCTION MANAGEMENT**

### **CE 798-799 Special Topics in Infrastructure Systems and Construction** 2½:0:3

Current topics of interest such as 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.

### **CE 820 Project Management** 2½:0:3

Specific management concepts and techniques related to management of special projects in research and development, construction, engineering, and data processing. Functional and administrative structures, coordination of activities, manpower planning, feasibility analyses, negotiations and contracts. **Also listed under MG 820.**

### **CE 825 Project Management for Construction** 2½:0:3

Topics specific to the development and coordination of large projects, including; organizational structures, management functions, pricing and estimating project costs, bidding and contracting, risk al-

location, scheduling, time and cost control, labor relations, quality management, as well as project life cycle activities. **Also listed under MG 825.**

### **CE 826 Construction Cost Estimating** 2½:0:3

Estimates, and costs from the viewpoint of contractor or construction engineer, details of estimating, emphasis on labor, material, equipment, overhead costs. **Also listed under MG 826.**

### **CE 827 Contracts and Specifications** 2½:0:3

Principles of contract law as applied to the construction industry; legal problems in preparing and administering construction contracts. **Also listed under MG 827**

### **CE 828 Project Planning and Control** 2½:0:3

Network planning techniques for project management and resource allocation. Emphasis on PERT, LOB, CPM and probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Network development, computer adaptation, progress reports and project monitoring. *Prerequisite: knowledge of computer programming.* **Also listed under MG 810 and IE 620.**

### **CE 829 Construction Operations Analysis** 2½:0:3

Evaluation and model development of productivity, safety, quality, and materials handling in construction operations. Principal methods for analysis and pre-planning of work activities, including the use of work sampling, questionnaires, and surveys. The implementation of video/timelapse photography in field studies, and the incorporation of crew balances, flow diagrams, process charts, and five-minute ratings for task measurements. The introduction of task analysis, including queuing theory, to the modeling and analysis of construction operations. Introduction to construction simulation. Field implementation and projects. *Prerequisite: degree in civil engineering, or approval of Adviser.*

**CE 830 Information Systems in Project Management** 2½:0:3

Development of a strong understanding of contemporary tools for managing the vast array of information in the project life cycle. Information handling is reviewed both from the perspective of knowledge acquisition and knowledge representation. Information analysis as qualitative and quantitative. Interpretation of knowledge as deterministic versus stochastic. Introduction to decision making under risk. The implementation of spreadsheets, databases and expert systems as information systems communication tools for project information handling. A review of technologies such as CAD databases, geographic information systems, decision support systems and videogrammetry as tools for project automation. *Prerequisite: Degree in civil engineering or approval of Adviser.*

**CE 831 Engineering for Construction I: Methods and Technologies** 2½:0:3

Planning, design and equipment for new construction and for infrastructure rehabilitation. Engineering fundamentals of earth moving, soil stabilization, and compaction. Methods for tunneling through rock and earth, as well as rock blasting. Foundation grouting, piles and pile driving equipment. Dewatering systems and pumping equipment. Factors affecting the selection of construction equipment. Review of conventional construction equipment and trends in robotics. *Prerequisite: Degree in civil engineering, or permission of instructor.*

**CE 832 Engineering for Construction II: Design** 2½:0:3

In-depth analysis of design methods for construction operations. Earth pressure analysis and structural analysis. Design for sheet pile walls, cofferdams, underpinning systems, tieback systems, and pipejacking systems. Details of a dewatering system design. Special studies in constructability and value engineering. *Prerequisite: CE 831, or permission of the instructor.*

**GEOTECHNICAL & GEO-ENVIRONMENTAL ENGINEERING**

*Prerequisites for all courses: MA 108, CE 232, CE 317*

**CE 849 Environmental Geotechnology** 2½:0:3

Chemical phase transfer. Acids and bases in soils. Chemical reactions in soils. Identification, clay mineralogy. Hydraulic conductivity, diffusion and unsaturated flow. Well hydraulics. Contaminant transport. Flow potentials. Seepage barriers. Bioremediation. *Prerequisites: CE 223.*

**CE 850 Ground Improvement** 2½:0:3

Classification of available technologies. Performance criteria. Physical and chemical soil behavior; testing and design parameters. Reinforced soil retaining systems; metal reinforcement and geotextiles. Chemical, thermal and physical ground treatment. Densification by vibro/dynamic ground replacement. Soil nailing and ground anchors. Design methods. Case histories. Environmental applications; seepage barriers, remediation. New trends in ground improvement.

**CE 851 Stress-Strain Behavior and Seepage** 2½:0:3

Conjugate stress relationships in infinite slopes in granular and cohesive soils. Studies of classical works of Rankine, Coulomb, Kerisel 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 861 Shear Strength of Soils and Limit Analysis** 2½:0:3

Index properties of soils. 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. Strength of soils.

**CE 862 Physical and Chemical Soil Behavior** 2½:0:3

Strength of soils, laboratory tests, effective strength parameters, total and effective stress paths. Applications of soil strength in stability analysis of embankments. Critical state soil mechanics, constitutive relations for soils. *Prerequisite: CE 861.*

**CE 863 Experimental Soil Mechanics** 1:2:3

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** 2½:0:3

Soil sampling and exploration procedures. Analytical procedures for determining bearing capacity as a function of stability and settlements. Plate-loading test shallow footing design. Analysis and design of mat footings. Design of deep foundations; piles, piers and caissons.

**CE 881-882 Special Topics in Geotechnical Engineering & Pavement Technology I, II** 2½:0:3

Current topics of interest such as theoretical determination of pile capacities, sheet pile bulkheads and trench problems, stress on tunnels, theoretical approaches to soil stability and settlement, soil reinforcement applications, pavement performance and rehabilitation, pavement management systems, pavement improvement techniques, pavement performance evaluation, recycling technologies, pavement on sensitive soils. *Prerequisite: CE 851, CE 861, CE 871 or CE 797 depending on subject area.*

**CE 892 Soil Dynamics and Earthquake Engineering** 2 1/2:0:3

Single- and multi-degrees of freedom systems. Wave propagation in homogeneous and layered half-spaces. Behavior of dynamically loaded soils. Basic concepts of seismology; earthquake distribution, type, magnitude, intensity, energy and seismic regionalization. Response spectrum. Effect of earthquakes on soil and response of structures to earthquakes as influenced by soil formation. Design of dynamically loaded foundations and earth structures. The liquefaction problem. *Prerequisite: CE 861.*

**CE 893 Rock Mechanics and Underground Structures** 2 1/2:0:3

Intact rock and rock mass description and engineering properties; static ground-structure interaction, stability and wedge analysis, underground structures in rock and soft soil.

**CE 895 Performance Monitoring and In-Situ Testing** 2 1/2:0:3

Introduction to soil and rock behavior. The "observational" method. Geotechnical instrumentation: types, applications, uncertainty. Planning a monitoring program. Case histories. The need for in-situ parameters. Penetration testing. Pressuremeter. Dilatometer. Stepped blade. Wave based methods (mechanical and electromagnetic). Case histories and controlled laboratory studies. New trends in monitoring and in-situ testing.

**GUIDED READINGS, SEMINARS, PROJECTS AND THESES**

**Note:** Students should obtain a copy of the University's "Regulations on Format, Duplication and Publication of Reports Theses and Dissertations" at the Office of Research and Graduate Affairs.

**CE 901 Guided Readings in Civil or Environmental Engineering** 3 units

Individual study of selected literature in civil or environmental engineering under guidance of a faculty adviser. Acceptable written report or successful completion of examination required. Only one

registration permitted, except with department head's approval. *Prerequisite: Instructor's approval.*

**CE 952 Seminar in Civil or Environmental Engineering** nc

Lectures on recent developments in civil or environmental engineering given by representatives from industry, other research and education institutions, and Polytechnic graduate students and faculty.

**CE 996 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, and following Department guidelines. Written report required. *Prerequisite: degree status and project adviser's approval.*

**CE 997 Thesis for the Degree of Master of Science** 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. Allowable registration per semester 3-12 units. *Prerequisite: degree status and thesis adviser's approval.*

**CE 999 Dissertation for Degree of Doctor of Philosophy** 6 units

Independent original investigation demonstrating creativity and scholarship worthy of publication in recognized engineering journals. Candidates must successfully defend their theses orally. Registration for minimum of 30 thesis units required prior to defense. Registration should be continuous. Preferred registration per semester, 6 units; allowable registration 1/2-18 units with approval of department head. *Prerequisites: degree status, completion of qualifying examinations and thesis adviser's approval.*

**FACULTY**

**Ilan Juran**, Professor of Civil Engineering, Head of Civil and Environmental Engineering Department. B.S.C.E. Technion (Israel); Ph.D., D.Sc. University of Paris VI, Ecole Nationale des Ponts et Chaussees  
*Geotechnical engineering, soil improvement technologies, geosynthesis engineering, in-situ soil testing*

**Alvin S. Goodman**, P.E., Professor of Civil Engineering  
B.C.E. CCNY; M.S.C.E. Columbia University; Ph.D. New York University  
*Comprehensive water resources planning; water supply studies; hydrologic estimates; systems analysis of water resources; groundwater mathematical models; conjunctive use of surface and ground water*

**Alan H. Molof**, Associate Professor of Environmental Engineering  
B.S.Ch.E. Bucknell University; M.S.E. (Ch.E.) M.S.E. (Sanitary Engineering) Ph.D. University of Michigan  
*Water and wastewater treatment processes; river and stream pollution; industrial waste treatment; hazardous/toxic waste management*

**Nancy M. Tooney**, Associate Professor of Biochemistry  
B.S., M.S. SUNY (Albany); Ph.D. Brandeis University  
*Structure and function of proteins and other biopolymers, blood clotting system, fibronectin structure and function, environmental chemistry*

**Janet K. Yates**, Associate Professor of Civil Engineering  
B.S.C.E., University of Washington Ph.D., Texas A&M University  
*International construction; international competitiveness; finance; constructibility; productivity; project planning and decision analysis.*

**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.*

**Dong-Soo Kim**, Assistant Professor of Civil Engineering  
 B.S.C.E., M.S.C.E., Seoul National University; Ph.D., University of Texas at Austin  
*Soil dynamics and earthquake engineering; subgrade soil characteristics; instrumentation; soil-structure interaction.*

**Say K. Ong**, P.E. Assistant Professor of Environmental Engineering  
 B. Eng. (ME) University of Malaya, M.S. (Env. Eng.) Vanderbilt University  
 Ph.D., Cornell University  
*Physical-chemical treatment processes for water quality control and hazardous waste management; aquatic chemistry; fate and transport of pollutants in the subsurface and surface water; wastewater treatment process modeling; toxic-ity reduction in wastewater.*

**Sotoris A. Pagdadis**, Assistant Professor of Civil Engineering  
 B.S. Eng. (A.S.E.), M.S. Eng. (E.M.), Ph.D. (C.E.) The University of Texas at Austin  
*Project mgmt. & construction engineering; automation; A.I., DBMS, CAD, systems modelling; productivity planning, constructibility; infrastructure rehabilitation and mgmt; quality management.*

**Angelos L. Protopapas**, P.E. Assistant Professor of Civil Engineering  
 Dipl. Eng. (C.E.), National Technical University of Athens (Greece), M.S. (Operations Research & Computer Sc), University of Athens (Greece)  
 M.S.C.E., Ph.D., Massachusetts Institute of Technology  
*Surface and groundwater hydrology and pollution; water resources systems; urban hydrology; fluid mechanics; irrigation*

**Theva S. Thevanayagan**, P.E. Assistant Professor of Civil Engineering  
 B.S., Peradeniya University (Sri Lanka); M.S.C.E., Ph.D., Purdue University  
*Geotechnical Engineering; environmental geotechnology; numerical modelling of soils; physico-chemical behavior of soils; in-situ testing.*

## ADJUNCT FACULTY

**Raul R. Cardenas, Jr.**, Adjunct Professor of Environmental Engineering  
 B.A., University of Texas; M.S., Ph.D., New York University

**Joseph C. Cataldo**, P.E. Adjunct Professor of Civil Engineering  
 B.C.E., M.S.C.E., Ph.D., CCNY

**Mohammad Karamouz**, P.E. Adjunct Professor of Civil Engineering  
 B.S.C.E., Pahlavi University (Iran); M.S.C.E., George Washington University; Ph.D., Purdue University

**Rita Meyniger**, Adjunct Professor of Environmental Engineering  
 B.S.C.E., Newark College of Eng., M.S.C.E. New York University  
 Ph.D., Polytechnic University

**John T. Tanacredi**, Adjunct Professor of Environmental Engineering  
 B.S. Richmond College, M.S., Hunter College Ph.D., Polytechnic University

**Constantine Yapijakis**, Adjunct Professor of Civil Engineering  
 M.C.E., National Technical University of Athens (Greece);  
 M.S., New York University; Ph.D., Polytechnic Institute of New York

**Sidhartha Bagchi**, P.E. Adjunct Associate Professor of Civil Engineering  
 B.A., Calcutta University; B.E.C.E., Calcutta University; M.E.C.E., Calcutta University; Ph.D., Polytechnic Institute of New York

**William F. Graner**, P.E. Adjunct Assistant Professor of Environmental Engineering  
 B.S.C.E., Ph.D., Polytechnic Institute of New York; M.C.E., New York University;

**Paul W. Grosser**, P.E. Adjunct Assistant Professor of Civil Engineering  
 B.E., M.E., Stevens Institute of Technology; Ph.D., Polytechnic Institute of New York

**Agememnon Koutsospyros**, Adjunct Assistant Professor of Environmental Engineering  
 Dipl. E. Chem. Eng., National University of Athens (Greece);  
 M.S.C.E., Ph.D., Polytechnic University

**Michael J. Sakala**, P.E. Adjunct Assistant Professor of Civil Engineering  
 B.S., Drexel University; M.S.C.E., Polytechnic Institute of New York

**Zohreh Shahvar**, Adjunct Assistant Professor of Civil Engineering  
 B.S. (Agr. E.) University of Tehran (Iran); M.S. (Water Resources); Ph.D. (Agr. E.), Iowa State University

# HUMANITIES AND COMMUNICATIONS

The Department of Humanities and Communications contributes to the undergraduate degree programs 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 and undergraduate programs 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 complete two courses in literature, art and music, philosophy or three courses in modern languages. Courses in public speaking and technical writing are especially practical for students preparing for careers in engineering or science. All students should check the special requirements of their departments. These requirements will be found in the Degree Requirements section at the front of this catalog and under the individual department's course listings. Up-to-date information about such requirements is also available from departmental advisers.

## UNDERGRADUATE PROGRAMS

The Department of Humanities and Communications offers Bachelor of Science degrees in Journalism and Technical Writing and Bachelor of Science degrees in Humanities.

### REQUIREMENTS FOR THE B.S. DEGREE IN JOURNALISM AND TECHNICAL WRITING

Our graduates have successful careers in journalism, science writing and technical writing. Science and technical writers in particular—those with the skills of journalists combined with strong interests in science and technology—continue to be in great demand. In these occupations, professional status and salaries are virtually on a par with those of engineers. Majors in journalism and technical writing arrange programs of studies in consultation with departmental advisers. Generally they also fulfill the requirements of the contemporary

liberal arts core curriculum outlined in the preceding section of this catalog. A maximum of nine credits in graduate courses in Specialized Journalism may be taken to satisfy the undergraduate degree requirements. These courses are usually taken no earlier than the second half of the junior year.

#### Core Curriculum: Credits

<i>Humanities (HU 101 and HU 200)</i>	6
<i>Social Sciences (SS 104)</i>	3
<i>Mathematics &amp; Computers (LA 120, 121, 125)</i>	11
<i>Science (LA 130, 131, 132)</i>	12

#### Interdisciplinary courses:

<i>(LA 110, 140, 141, 142, 143, 144, 150, 160)</i>	25
<i>Journalism and Technical Writing Courses</i>	33

#### Electives:

<i>Humanities electives</i>	6
<i>Social Sciences electives</i>	6
<i>Free electives</i>	<u>24</u>
<i>Total credits required for graduation</i>	126

### REQUIREMENTS FOR THE B.S. DEGREE IN THE HUMANITIES

For students wishing to pursue a degree in the humanities, the department offers specializations in literature, philosophy, and general humanistic studies (a multidisciplinary major in the humanities). Here, too, students work out a program of studies in consultation with a departmental adviser. Generally they also fulfill the requirements of the contemporary liberal arts core curriculum outlined in the preceding section of this catalog. 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.

**OTHER UNDERGRADUATE DEPARTMENTAL PROGRAMS**

**Dual undergraduate degrees** — A few students elect to pursue dual undergraduate degrees—one in journalism and technical writing and another in engineering, science or mathematics. Besides completing all requirements for degrees in engineering (136 credits), science (128 credits), or mathematics (128 credits), students must complete an additional 33 credits of communications courses in the Department of Humanities and Communications, for a total of 161 or 169 credits. These courses must be approved by a departmental adviser. Other combinations are possible, such as dual degrees in the humanities and either social sciences or management.



The Department of Humanities and Communications offers a master of science degree 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 an excellent command of English and should have taken as undergraduates at least one semester of college-level mathematics and one year of college-level science (to be met by any combination of courses in biology, chemistry, physics, geology, geography, engineering and history of science). Applicants lacking any of these courses may be matriculated on a provisional basis—as long as they meet all other requirements for admission—but are required to take undergraduate 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 undergraduate 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 students. Applicants are not required to take the Graduate Record Examination.

**FIELDS OF SPECIALIZATION**

**Business-Magazine Journalism**

Trade-magazine journalism entails writing and editing news and feature articles for technical and marketing-oriented publications serving particular industries. Such publications may be owned by independent publishing companies, professional societies or large corporations.

**Financial Reporting**

Financial and business reporting calls for professional journalists who can write about business and finance for knowledgeable business professionals and market analysts as well as the general public. Writers should have a solid background in economics and a clear understanding of business and financial concepts and terminology (including the workings of the various exchanges) in order to report and interpret developments accurately and comprehensibly. Clear, crisp, concise writing is a necessity.

**Industrial Advertising and Public Relations**

Industrial advertising and public relations work is concerned with the promotion of corporate 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 of 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 business magazines and technical journals, write speeches for engineering and management personnel and prepare literature (product brochures, annual reports, house organs and other technical and semi-technical material) for distribution to corporate customers.

**Medical and Science Reporting**

Medical and science writers or editors work on magazines serving physicians, nurses and other technical and scientific personnel; on the news staffs of print and broadcast media; on public relations staffs of pharmaceutical houses and 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.

**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 business-magazine articles for scientists and engineers.

## HUMANITIES AND COMMUNICATIONS

### REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The M.S. degree requires 36 units of graduate work. All students must take JW 605 (Libel Law and Press Ethics), JW 701 (Special Project in Professional Writing) and four courses (12 units) selected from the following list in consultation with an adviser:

	Units
JW 600 <i>Introduction to Specialized Journalism</i>	3
JW 601 <i>Style for the Professional Writer</i>	3
JW 602 <i>Proposal Writing</i>	3
JW 603 <i>Reporting on Science, Technology and Medicine</i>	3
JW 604 <i>Graphics and Production Techniques</i>	3
JW 607 <i>Writing News for Radio and Television</i>	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.

### Business-Magazine Journalism

	Units
JW 511 <i>Technical Writing about Digital Electronics</i>	4
JW 608 <i>Introduction to Documentation</i>	3
JW 609 <i>Computer Documentation</i>	3
JW 620 <i>Financial and Business Reporting</i>	3
JW 621 <i>Reporting and Editing for the Business Press</i>	3
JW 622 <i>Writing Copy for Industrial Public Relations</i>	3
JW 624 <i>Writing Product-Information Copy</i>	3
JW 641 <i>Graphics Workshop</i>	3
JW 701 <i>Special Project in Professional Writing</i>	3

### Financial Reporting

JW 608 <i>Introduction to Documentation</i>	3
JW 609 <i>Computer Documentation</i>	3
JW 620 <i>Financial and Business Reporting</i>	3
JW 621 <i>Reporting and Editing for the Business Press</i>	3
JW 622 <i>Writing Copy for Industrial Public Relations</i>	3
JW 623 <i>Publications Management and Budgeting</i>	3
JW 641 <i>Graphics Workshop</i>	3
JW 701 <i>Special Project in Professional Writing</i>	3

### Industrial Advertising and Public Relations

JW 608 <i>Introduction to Documentation</i>	3
JW 609 <i>Computer Documentation</i>	3
JW 621 <i>Reporting and Editing for the Business Press</i>	3
JW 622 <i>Writing Copy for Industrial Public Relations</i>	3
JW 624 <i>Writing Product-Information Copy</i>	3
JW 628 <i>Writing Industrial Advertising Copy</i>	3
JW 629 <i>Writing the Marketing Report</i>	3
JW 641 <i>Graphics Workshop</i>	3
JW 710 <i>Special Project in Professional Writing</i>	3

### Medical and Science Reporting

JW 603 <i>Reporting on Science, Technology and Medicine</i>	3
JW 608 <i>Introduction to Documentation</i>	3
JW 609 <i>Computer Documentation</i>	3
JW 621 <i>Reporting and Editing for the Business Press</i>	3
JW 625 <i>Advanced Medical Reporting</i>	3
JW 626 <i>Medical Public Relations</i>	3
JW 627 <i>Writing Copy on Pharmaceuticals and Drugs</i>	3
JW 641 <i>Graphics Workshop</i>	3
JW 701 <i>Special Project in Professional Writing</i>	3

### Technical Writing

JW 511 <i>Technical Writing about Digital Electronics</i>	4
JW 603 <i>Reporting on Science, Technology and Medicine</i>	3
JW 608 <i>Introduction to Documentation</i>	3
JW 609 <i>Computer Documentation</i>	3
JW 622 <i>Writing Copy for Industrial Public Relations</i>	3
JW 624 <i>Writing Product-Information Copy</i>	3
JW 630 <i>Basic Technical Report Writing I</i>	3
JW 631 <i>Basic Technical Report Writing II</i>	3
JW 632 <i>Writing Technical Manuals</i>	3
JW 641 <i>Graphics Workshop</i>	3
JW 701 <i>Special Project in Professional Writing</i>	3

### GRADUATE CERTIFICATE PROGRAMS IN FIELDS 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, specialized journalism, management, and the social sciences.



### HU 008 Reading and Writing in English as a Second Language 6:0:0:0

English as a second language at the high-intermediate level. Development of grammatical control in writing and improved comprehension of college-level texts. Practice in listening and speaking; intensive preparation in language skills for academic and professional purposes. Graduate students may register with permission of department. Admission by placement examination.

**HU 009 Introductory Composition** 6:0:0:0

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** 3:0:0:3

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 emphases 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)** 6:0:0:3

Introduction to the humanities and to effective techniques of college-level writing, designed for students for whom English is a second language. Examination of basic concepts, forms and techniques of philosophy, art and literature, with emphases on fluency, grammar, syntax, precision and imaginative use of source materials in writing. Admission by placement examination.

**HU 200 Writing and the Humanities II** 3:0:0:3

Introduction to the humanities and to advanced techniques in writing. Thematic emphasis on change and continuity in the humanities and an exploration of the interrelationship of the humanistic disciplines through study of great works of art, philosophy, literature and, in some sections, music. Advanced work in stylistic options and more complex forms of writing: the longer critical study, the formal report, the research paper. In some cases, this course may be presented as an introduction to literature, covering poetry, short stories, and novels. *Prerequisite: HU101 or 103 or advanced placement.*

**JOURNALISM AND TECHNICAL WRITING, COMMUNICATIONS**

**HU 105 Advanced Composition** 3:0:0:3

Lucid expository writing. Gathering and organization of factual material into larger units of composition. Methods of research and uses of library. Topics based on models of expository prose. Long paper. *Prerequisite: HU 101 or HU 103.*

**HU 106 Writing for Publication: The Magazine Article** 3:0:0:3

Development of students' interviewing and writing skills to produce 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. *Prerequisite: HU 101 or HU 103.*

**HU 108 News Writing** 3:0:0:3

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. *Prerequisite: HU 101 or HU 103.*

**HU 109 Feature Writing** 3:0:0:3

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 slanting, in dramatizing, in outlining and writing minimum of three articles. *Prerequisite: HU 101 or HU 103.*

**HU 110 Professional Report Writing** 3:0:0:3

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. *Prerequisite: HU 200.*

**HU 112 Advanced Copyediting Techniques** 3:0:0:3

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. *Prerequisite: HU 101 or HU 103.*

**HU 113 Writing for Advertising and Public Relations** 3:0:0:3

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. *Prerequisite: HU 101 or HU 103.*

**HU 115 Reporting and Writing about Science and Technology** 3:0:0:3

How to interview scientists and engineers and how to present the information obtained in formats understandable to the layperson. Students write both news and feature stories—and are encouraged to publish their best pieces. *Prerequisite: HU 101 or HU 103.*

## HUMANITIES AND COMMUNICATIONS

### HU 116 Introduction to Computer Documentation 3:0:0:3

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. Prerequisite: HU 101 or HU 103.*

### HU 118 Public Speaking Seminar 1:0:0:1

Preparation and delivery of oral presentations with emphasis on technical and industrial topics. Students will conduct personal or phone interviews with sources in the research phase of their assignments. Practice in making team presentations. Students will learn to incorporate graphics into their talks. Critiques by instructor and fellow students. *Prerequisites: HU 101 or HU 103 and HU 200.*

### HU 120 Public Speaking and Pronunciation 2:0:0:2

Training and practice in speaking before groups, preparation of materials for oral presentations, discussion and interviewing techniques, extemporaneous speaking, pronunciation and speaking of English. This course is only for intermediate English as a Second Language students who are required to take HU 008 as a result of the English Composition Placement.

### HU 121 Public Speaking 3:0:0:3

Training and practice in speaking before groups, preparation of materials for oral presentations, discussion and interviewing techniques, extemporaneous speaking. Not open to students who were required to take HU 008.

### HU 130 Creative Writing I 3:0:0:3

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. *Prerequisite: HU 101 or HU 103.*

### HU 131 Creative Writing II 3:0:0:3

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 3:0:0:3

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, formats for minutes of meetings and job descriptions. *Prerequisite: HU 101 or HU 103.*

### HU 141 Graphics and Productions Techniques 3:0:0:3

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 atmosphere. *Prerequisite: HU 101 or HU 103.*

### HU 150-151 Special Projects in Communications each 3:0:0:3

Independent work in an area of communications selected by student in consultation with instructor. For majors only. *Prerequisite: HU 101 or HU 103.*

### HU 155 Special Topics in Journalism 3:0:0:3

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. *Prerequisite: HU 101 or HU 103.*

## LITERATURE

*(See also Literature in Translation and Interdisciplinary Studies, below)*

### HU 203 Literature of Western Civilization III 3:0:0:3

Intellectual and cultural, moral and spiritual values of the modern world in novels, drama, philosophy, poetry. Literature of the Romantic revolt, Goethe, Dostoevski, Brecht, Sartre, Solzhenitsyn, American and European poetry. *Prerequisite: HU 200.*

### HU 211 English Literature from Beowulf to 1800 3:0:0:3

English literature from Beowulf through Chaucer, the Elizabethans and the Jacobans to 1800. *Prerequisite: HU 200.*

### HU 212 English Literature from 1800 to Present 3:0:0:3

English literature from the Romantics to the present (Wordsworth, Byron, Dickens, Tennyson, Shaw, Conrad, Beckett and others). *Prerequisite: HU 200.*

### HU 213 Science and Literature 3:0:0:3

With emphasis on the 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, Heinar Kipphart, James Watson, Kurt Vonnegut and Isaac Asimov. *Prerequisite: HU 200.*

### HU 222 Shakespeare 3:0:0:3

Representative tragedies, comedies, histories. Cultural, social and literary influences. Textual problems, recent criticism, Elizabethan theater. *Prerequisite: HU 200.*

### HU 251 American Literature to 1880 3:0:0:3

The puritan and neoclassic periods through the romantic movement and the rise of realism. Jonathan Edwards, Paine, Irving, Poe, Hawthorne, Emerson, Thoreau, Whitman, Twain, James and others. *Prerequisite: HU 200.*

**HU 252 American Literature from 1880 to Present** 3:0:0:3

Major American writers from 1880. Background and thought of Crane, Dreiser, Robinson, Frost, Millay, Sandburg, O'Neill, Cather, Wharton, Lewis, Hemingway, Fitzgerald, Wolfe, Faulkner. *Prerequisite: HU 200.*

**HU 262 Contemporary American Novel** 3:0:0:3

The contemporary American novel as affirmative expression of the human situation. Technical and philosophical analyses of such writers as Golding, Salinger, Updike, Roth, Vonnegut, Clarke, Bellow and others. *Prerequisite: HU 200.*

**HU 264 The Short Story** 3:0:0:3

Themes, structure, techniques of short stories by writers as diverse in style and philosophy as Chekhov, Twain, O. Henry, Mansfield, Lardner, Faulkner, Thurber and Hemingway. *Prerequisite: HU 200.*

**HU 281 Comedy** 3:0:0:3

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. *Prerequisite: HU 200.*

**HU 283 Modern American Drama** 3:0:0:3

Technical and philosophical analyses of O'Neill, Miller, Anderson, Hellman, Williams, Inge, Albee and others. Some contemporary American films may be included. *Prerequisite: HU 200.*

**HU 291 Short Fiction** 3:0:0:3

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, Nathanael West. Class discussions, cinematic presentations of some works and theater visits are integral to course. *Prerequisite: HU 200.*

**PHILOSOPHY AND COMPARATIVE RELIGION**

**HU 341 Introduction to Philosophy** 3:0:0:3

An initial inquiry into problems, methods and terminology of Western philosophy through study and discussions of selected philosophical texts. *Prerequisite: HU 200.*

**HU 344 Introduction to Logic** 3:0:0:3

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. *Prerequisite: HU 200.*

**HU 346 Ethical Theories** 3:0:0:3

A study of one or more major ethical theories. The nature of human action, distinctions between good and bad, virtue, sources of obligation, freedom of action, human valuation and conscience. *Prerequisite: HU 200.*

**HU 347 Ethics and Technology** 3:0:0:3

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. *Prerequisite: HU 200.*

**HU 348 Great Philosophers I** 3:0:0:3

Selected works of such philosophers as Plato, Aristotle, the Stoics, neo-Platonists, St. Augustine, Maimonides, St. Thomas Aquinas. *Prerequisite: HU 200.*

**HU 349 Great Philosophers II** 3:0:0:3

Philosophy from the Renaissance to the 19th century, emphasizing the rationalist tradition (Descartes, Spinoza, Leibniz), the empiricist tradition (Bacon, Locke, Hume) and Kant. *Prerequisite: HU 200.*

**HU 352 Philosophy of Science** 3:0:0:3

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. *Prerequisite: HU 200.*

**HU 353 Philosophy of Technology** 3:0:0:3

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. *Prerequisite: HU 200.*

**LA 139 Engineering Ethics** 2:0:0:2

An introduction to professional engineering ethics presented through the history of engineering, codes of conduct of the professional societies, contemporary case studies, and discussion of hypothetical situations. No essential duplication of HU 347 or IE 302. *Prerequisite: HU 200.*

**LA 143 Computers, Cultures and Society** 3:0:0:3

Explores the nature of information, communications, and their associated systems and technologies; introduction to information theory and information processing; cultural, economic, and political implications of the communications-computer revolutions.

**MUSIC AND FINE ARTS**

**HU 371 Understanding of Music** 3:0:0:3

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. *Prerequisite: HU 200.*

## HUMANITIES AND COMMUNICATIONS

### HU 375 Modern Music 3:0:0:3

Music from 1850 to present: Wagner, Strauss, Mahler, Debussy, Stravinsky, Ives, Schoenberg, Berg, Weber, Varese. Revolt against romanticism; breakdown of traditional tonal-harmonic system. Polyharmony, polytonality, pantonality, melodic fragmentation, aleatory and electronic music as expressions of the 20th century. Jazz, modern popular music and music of other cultures. *Prerequisite: HU 200.*

### HU 382 Fine Arts I 3:0:0:3

Historical and analytical study of Western architecture, sculpture, painting. Egyptian, Greek, Roman architecture and sculpture. Gothic and Renaissance art. Parallel trends in other arts. *Prerequisite: HU 200.*

### HU 383 Fine Arts II 3:0:0:3

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. *Prerequisite: HU 200.*

### 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 3:0:0:3

*Prerequisite: HU 200.*

### HU 301 Special Topics in Literature 3:0:0:3

*Prerequisite: HU 200.*

### HU 302 Special Topics in Philosophy 3:0:0:3

*Prerequisite: HU 200.*

### HU 303 Special Topics in Music and Fine Arts 3:0:0:3

*Prerequisite: HU 200.*

## MODERN LANGUAGES

**Note:** Students must begin a language sequence at the level of their proficiency. Normally students who have had two years of a language in high school would begin with the third semester of a language in college. If in doubt about the level of proficiency, a student should consult the appropriate instructor in the department.

### FRENCH

#### ML 131 French I: Foundation Course 3:0:0:3

For students with no previous training in French. Development of proficiency in reading, comprehension, speaking. Early practice in reading original French prose and representative poems.

#### ML 132 French II 3:0:0:3

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 3:0:0:3

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 3:0:0:3

Continuation of ML 133. Reading of cultural, philosophical, scientific subjects. Practice in conversational French. *Prerequisite: ML 133 or equivalent.*

### SPANISH

#### ML 161 Spanish I: Foundation Course 3:0:0:3

For students with no previous training in Spanish. Development of proficiency in reading, comprehension, speaking. Early practice in reading original Spanish prose and representative poems.

#### ML 162 Spanish II 3:0:0:3

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 3:0:0:3

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 3:0:0:3

Continuation of ML 163. Reading of cultural and philosophical subjects. Practice in conversational Spanish. *Prerequisite: ML 163 or equivalent.*

### JAPANESE

#### ML 171 Japanese I 3:0:0:3

For students with no previous training in Japanese. Development of proficiency in reading, comprehension and speaking.

#### ML 172 Japanese II 3:0:0:3

Continuation of foundation provided in ML 171. Reading of Japanese literature included.

#### ML 173 Japanese III 3:0:0:3

Continuation of foundation provided in ML 172.

## GRADUATE COURSES

### SPECIALIZED JOURNALISM

#### 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 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 Libel Law and Press Ethics** 2½:0:3

Based on a study of some classic cases, this course will familiarize the student with the essentials of libel law necessary when writing for publication. Journalistic ethics and writer's responsibilities to sources and readers are also considered.

**JW 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 621 Reporting and Editing for the Business Press** 2½:0:3

The need exists on business and trade magazines—both technical and non-technical—for reporters and editors with solid journalistic skills and a knack for digging out facts. This course surveys the diverse editorial opportunities in business-press journalism and helps the student develop the necessary skills in writing, editing and interviewing that such publications demand. Among the assignments: writing short news stories, copy-editing (including the writing of heads and decks), rewriting weak copy for a magazine's departments (new products, books and literature, case histories, news, company and personality profiles, etc.), short features describing plant layouts, machine operation, maintenance procedures and business conditions. Consideration will be given also to the longer feature article often referred to as the roundup story. Since most specialized business (trade) magazines serve a particular field of industry (automotive, electronics, petrochemicals, etc.), many of the articles appearing in them are contributed by industry authorities. The course will emphasize the responsibility of the editor to cultivate good working relationships with such people to induce them to write.

**JW 622 Writing Copy for Industrial Public Relations** 2½:0:3

A workshop approach to doing public relation work for a corporation requiring both product and corporate publicity. Course covers the PR functions from the standpoint of both the in-house staffer and the account executive at the agency. Among the subjects taken up: publicity methods used to introduce a new product, writing the standard press release, preparation of the technical article dealing with a phase of the company's expertise, writing and placement of case histories, arranging press conferences and plant tours, handling press inquiries, writing speeches. The course also considers the working relationship that develops between the PR agency and the in-house staff of the client in cases where companies utilize both services.

**JW 625 Advanced Medical Reporting** 2½:0:3

Writing on medical and biological subjects, with emphasis on interviewing. Students will gather much of the information for their writing assignments from sources in the field and will prepare articles for the general press, semi-technical reports for pharmaceutical houses, articles for professional magazines and sales and promotional literature for medical products.

**JW 626 Medical Public Relations** 2½:0:3

The special considerations, responsibilities and problems faced by public relations officials at medical research facilities, hospitals, medical schools, foundations and fund-raising organizations and pharmaceutical companies. Emphasis on writing medical and pharmaceutical press releases, brochures, film scripts, other in-house publications, speeches, press kits for press briefings. Visits to medical facilities to talk with public relation officials and research scientists.

**JW 628 Writing Industrial Advertising Copy** 2½:0:3

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

## HUMANITIES AND COMMUNICATIONS

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 630 Basic Technical Report Writing I** 2½:0:3

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 632 Writing Technical Manuals** 2½:0:3

Intensive practice in preparing industrial and military technical instructions 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 641 Graphics Workshop** 2½:0:3

A workshop devoted to the actual production of technical graphics—charts, graphs, newsletters, etc. *Prerequisite: JW 604 or equivalent.*

### **JW 701 Special Project in Professional Writing** 2½:0:3

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** 2½:0:3

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. May be repeated for credit.

## **THE FOLLOWING COURSES ARE OFFERED IRREGULARLY IN RESPONSE TO STUDENT DEMAND:**

### **Journalism and Technical Writing, Communications:**

- HU 111 Basic Report Writing
- HU 114 Libel Law and Ethical Issues in Journalism
- HU 125 Reporting and Writing for the Wire Service
- HU 136 Writing Annual Reports
- HU 140 Proposal Writing
- HU 142 Writing Operation and Maintenance Manuals
- HU 160 Writing the News for TV and Radio
- HU 161 Writing and Producing Documentaries

### **Literature:**

- HU 201 Literature of Western Civilization I
- HU 202 Literature of Western Civilization II
- HU 258 American Thought
- HU 272 Contemporary American Poetry
- HU 295 Literary Interpretation and Criticism
- HU 297 English Language

### **Philosophy and Comparative Religion:**

- HU 345 Advanced Logic
- HU 354 Social and Political Philosophy
- HU 363 World Religions
- HU 364 Philosophy of Religion
- HU 365 Science, Technology and Religion

### **Music and Fine Arts:**

- HU 389 Art of Asia

### **German:**

- ML 111 German I: Foundation Course
- ML 112 German II
- ML 113 German III: Readings in German Literature Since 1800

- ML 114 German IV
- ML 115 Conversation and Composition
- ML 121 Scientific German I
- ML 122 Scientific German II
- ML 213 German Drama from 1800 to Present
- ML 214 Contemporary German Literature
- ML 215 Goethe's *Faust*, Part I
- ML 216 Goethe's *Faust*, Part II
- ML 217-18 German Thought from Kant to Present I, II

### **French:**

- ML 135 Conversation and Composition
- ML 235-36 French Thought from Rabelais to Sartre I,II
- ML 237 Contemporary French Literature
- ML 238 French Civilization

### **Russian:**

- ML 151 Russian I: Foundation Course
- ML 152 Russian II
- ML 153 Russian III: Readings in 19th-Century Russian Literature
- ML 154 Russian IV
- ML 155-56 Contemporary Russian Literature and Civilization

### **Spanish:**

- ML 265-66 Culture of Latin America, I, II

### **Literature in Translation:**

- ML 311 Currents of Unrest in 20th Century: German Literature (in English translation)
- ML 312 Currents of Unrest in 20th Century: French Literature (in English translation)
- ML 313 Currents of Unrest in 20th Century: Russian Literature (in English translation)
- ML 318 The Hebrew Bible
- ML 319 The Jewish Heritage

### **Linguistics:**

- ML 381 Language and Society
- ML 382 Introduction to the Study of Language
- ML 383 Advanced Topics in Study of Language

### **Specialized Journalism:**

- JW 511 Technical Writing and Digital Electronics
- JW 602 Proposal Writing
- JW 606 Oral Technical Presentations
- JW 607 Writing the News for Radio and TV
- JW 620 Financial Reporting
- JW 623 Publications Management and Budgeting
- JW 624 Writing Product-Information Copy
- JW 627 Writing Copy on Pharmaceuticals and Drugs
- JW 629 Writing the Marketing Report
- JW 631 Basic Technical Report Writing II
- JW 640 The Video Documentary

### **English and Humanistic Studies:**

- HU 521 Seminar in Oral English
- HU 522 Seminar in Written English

**FACULTY**

**Anne Eisenberg**, Professor of Humanities and Communications; Head of Department  
B.A., Barnard College; M.A., University of Iowa; Ph.D., New York University  
*Science Writing*

**Wolhee Choe**, Professor of English  
B.A., Adelphi University; M.A., Ph.D., City University of New York  
*Nineteenth-century English literature, literary theory, English as a second language*

**Duane DeVries**, Associate Professor of English  
B.A., Kalamazoo College; M.A., Ph.D., Michigan State University  
*Dickens, the nineteenth-century English novel, expository writing*

**Sylvia Kasey Marks**, Associate Professor of English  
B.A., M.A., University of Michigan; Ph.D., Princeton University  
*Shakespeare, Samuel Richardson, the eighteenth-century British novel, public speaking*

**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*

**Enid Dame**, Assistant Professor of English  
B.S., Towson State College; M.A., The City College, City University of New York; Ph.D., Rutgers University  
*Victorian literature, expository writing, creative writing, poetry, American fiction, feminist biblical revisionism*

**Harold Sjurson**, Assistant Professor of Philosophy and Director, Philosophy and Technology Studies Center  
A.B., St. Olaf College; M.A., Ph.D., Graduate Faculty of Political and Social Science, New School for Social Research; Additional Study, University of Copenhagen  
*History of Philosophy, Ethics, Philosophy of Science and Technology*

**ADJUNCT FACULTY**

**Michael Arky**, Adjunct Instructor of Speech  
B.A., Brooklyn College

**Jodi A. Don**, Adjunct Instructor of Speech  
B.A., SUNY/Binghamton; M.S., Boston University

**Reva Ehrlich**, Adjunct Assistant Professor of Speech  
B.A., M.A., Brooklyn College, City University of New York; M.A., Queens College, City University of New York; Doctor of Arts, St. John's University

**Barbara Feknous**, Adjunct Instructor of English  
B.A., Vassar College; M.A., New York University

**Reva T. Field**, Adjunct Instructor of English  
B.A., M.A., Adelphi University

**Peter Fusco**, Adjunct Instructor of English  
B.A., Hunter College, City University of New York

**Daniel Gabriel**, Adjunct Assistant Professor of English  
B.A., The City College, City University of New York; M.A., The City College, City University of New York; M. Phil., The Graduate School, City University of New York; Ph.D., The Graduate School and University Center, City University of New York

**Suzanne Darrow-Kleinhaus**, Adjunct Instructor of Technical Writing; B.A., Hofstra University

**Linda Lerner**, Adjunct Instructor of English  
B.A., M.A., Brooklyn College, City University of New York

**Barbara Lynch**, Adjunct Instructor of Speech  
B.A., State University of New York at Oneonta; M.A., Teachers College, Columbia University

**Alison Menzie**, Adjunct Assistant Professor of English  
B.A., Ph.D., University of Liverpool

**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

**Cynthia Riley**, Adjunct Instructor of English  
B.A., University of Alabama at Birmingham; M.F.A., University of Alabama at Tuscaloosa

**Colleen M. Sandford**, Adjunct Assistant Professor of English  
B.A., Washburn University; M.A., Ph.D., University of Illinois

**Balram Tuls**, Adjunct Instructor of English  
B.S.E., University of Guyana; M.Sc., Polytechnic University

**Patricia Sisson**, Adjunct Instructor of English  
B.A., St. Francis College; M.A., Fordham University

**EMERITUS FACULTY**

**John G. Cavanna**, Professor Emeritus  
Ph.D., University of Minnesota

**Clifford Osborne**, Professor Emeritus  
M.A., University of Denver

**Bernard Rechtschaffen**, Professor Emeritus  
Ph.D., New York University

# INDUSTRIAL ENGINEERING

The Department of Mechanical and Industrial Engineering offers a program in industrial engineering master's level.

Industrial engineering addresses *how* systems operate, and is concerned with the effective and efficient delivery of quality products and services. The tools include analytic modeling, system simulation, queueing systems, work design, project planning, facilities design, and quality management and control. Courses are available in each of these topics, many with course projects suited to the practice-oriented degree offered at Polytechnic.

Many students seek a graduate degree in industrial engineering after completing an undergraduate degree in another engineering discipline. Because industrial engineers often work on multi-discipline teams, students are encouraged to use their electives to add strength in some area related to their career interests, such as:

Mechanical engineering  
Manufacturing  
Operations management  
Construction management

The graduate adviser will work with the student to develop a suitable program for either full-time or part-time study, with a product or service orientation

There are opportunities in many diverse areas. For example, industrial engineers are called upon to:

- Design quality into products and processes;
- Apply the principles of total quality management (TQM);
- Develop efficient work methods;
- Locate facilities and design plant layouts;
- Improve productivity and competitiveness;
- Schedule and manage projects;

- Use computers to simulate physical systems and processes;
- Apply their knowledge in manufacturing and service industries, including finance, health care, logistics, and construction.

Industrial engineers seek to allocate limited resources in an effective 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. Industrial engineers are thus in a strategic position to bring about the best integration of people, materials, machines, time and money in any endeavor.

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 move from the analysis and design of productive systems to the administration of those systems. While engineering and management are different fields, both require the ability to make decisions based on valid information. Industrial engineers are especially trained to obtain and evaluate such information.

## **REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE**

The general Polytechnic 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.

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.

The requirements for the MS(IE) are identified in four groups, plus a computer literacy prerequisite. Courses in Group B may be waived if equivalent courses were taken previously. In such cases, additional Group D courses may be taken.

All students must have a Program of Study (POS) on file, which describes the approved plan of study for the degree.

### **Prerequisite**

Knowledge of programming methodology, including exposure to at least one higher-level language (Fortran, C, or other). Students without this knowledge must take CS531 or CS532 or an equivalent course without credit toward the degree.

### **Group A: Basic Required Courses**

≤ 9 units

Students must have a knowledge of engineering economy, work design, analytic modeling, and probability and statistics. Course work in each of these areas must be demonstrated. If the prospective student lacks the relevant knowledge, it may be satisfied by the following:

**Engineering economy:** Attend the IE300 lectures, sit for a departmental examination, and undertake a specified project while registered for IE930 as part of the Group A requirement;

**Work Design:** Take IE606 (Work Design and Measurement) or MG616 (Job and Workplace Design), as part of the Group A requirement;

**Analytic modeling:** Take at least IE627-628 as part of the Group A requirement, or demonstrate competence by selecting as Group D electives at least one of the following: IE618, IE650, MA813, IE685;

**Probability and Statistics:** Take at least MA551 or MA561-562 as part of the Group A requirement, or demonstrate competence by selecting as a Group D elective at least two advanced relevant courses in the Department of Mathematics.

In no case may courses taken as part of the Group A requirement be used for more than nine units toward the MS(IE).

**Group B: Required Courses 15 units**

- IE 611 *Quality Control and Improvement*
- IE 619 *Production Planning and Control (Project Planning and Control) or MG820 (Project Assessment and Management)*
- IE 620 *Project Planning and Control or MG820 (Project Assessment and Management)*
- IE 621 *Facility Planning and Design*
- IE 682 *Systems Simulation, with Factory and Other Applications*

**Group C: Major Electives 9 units**

Select at least two of the groups shown below, and take at least one course from each group. Additional courses from any group may be used as Group D electives.

**Group C1**

- IE 788 *Manufacturing Systems Engineering*
- IE 785 *Computer Integrated Manufacturing Systems (CIMS)*
- IE 792 *Design for Manufacturability*

**Group C2**

- IE 612 *Quality Engineering Using Robust Design*
- MG 635 *Introduction to TQM*
- IE 685 *System Reliability*

**Group C3**

- ME 660 *Discrete Time Feedback Control*
- ME 600 *Applied Computational Methods*
- ME 700 *Finite Elements*
- ME 718 *Thermal Issues in Manufacturing Processes*

**Group C4**

- MG 820 *Project Assessment and Management*
- MG 825 *Construction Administration*
- MG 826 *Construction Estimates and Costs*
- MG 827 *Specification and Contracts*

**Group C5**

- IE 645 *Productivity Management*
- MG 617 *Performance Measurement and Reward Systems*
- MN 618 *Introducing New Methods: Leading Change*

**Group C6**

- MA 703 *Linear Algebra*
- MA 813 *Linear Programming (Queuing Systems) or MA815 (Theory of Queues)*

**Group D: Other Approved Electives ≤ 12 units**

Select other appropriate courses in consultation with the adviser. Concentrations in areas suited to the student's career interest are encouraged, such as mechanical engineering, manufacturing, operations management, and construction management. Courses from computer science (such as data bases, or EDI) or from management (such as new enterprise and small business management) may supplement such a concentration. Courses such as manufacturing resource planning (IE776) or industrial safety engineering (IE775) may also be used in Group D.

**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 a student has taken the equivalent of any required courses 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.

**Basic Industrial Engineering:**

- MA 551 *Applied Statistics I*
- IE 611 *Quality Control and Improvement*
- IE 621 *Facility Planning and Design*
- IE 682 *Systems Simulation, with Factory and Other Applications*

- IE 606 *Work Design and Measurement or*
- MG 616 *Job and Workplace Design*

**Advanced Industrial Engineering:**

- IE 612 *Quality Engineering Using Robust Design*
- IE 619 *Production Planning and Control*
- IE 645 *Productivity Management OR*
- MG 617 *Performance Measurement and Reward Systems*
- MN 618 *Introducing New Methods: Leading Change*
- IE 620 *Project Planning and Control or*
- MG 820 *Project Assessment and Management*

**Quality Control & Reliability:**

- MA 551 *Applied Statistics I*
- IE 611 *Quality Control and Improvement*
- IE 612 *Quality Engineering Using Robust Design*
- MG 635 *Introduction to TQM*
- IE 685 *System Reliability*

**Production & Inventory Control:**

- IE 618 *Inventory Models*
- IE 619 *Production Planning and Control*
- IE 620 *Project Planning and Control or*
- MG 820 *Project Assessment and Management*

plus two of the following:

- IE 621 *Facility Planning and Design*
- IE 788 *Manufacturing Systems Engineering*
- IE 785 *Computer Integrated Manufacturing Systems (CIMS)*

**GRADUATE COURSES**

**IE 606 Work Design and Measurement 2:1:0:3**

Principles and techniques of designing work methods and work simplification programs. Theory and techniques of work measurement, including time study, work sampling and standard data systems. Laboratory sessions in methods analysis, rating, work allowances and time study.

**IE 611 Quality Control and Improvement 2 1/2:0:0:3**

Review of the concepts of the cost of quality, quality assurance, quality process control, and total quality management. Emphasis on process and product design changes to improve qual-

## INDUSTRIAL ENGINEERING

ity and on process management and control. Control charts and their use: the concept of "out of control"; charts based upon variables and charts based on attributes. Specifications and tolerances. Acceptance sampling by lots, including concepts of producer's and consumer's risks. Course projects required. *Prerequisite: MA 562.*

### **IE 612 Quality Engineering Using Robust Design** 2½:0:0:3

The fundamental principles of robust design and quality loss practised by G. Tenuchi are developed. Design of experiment techniques using orthogonal arrays are discussed in detail as well as other methods for product/process improvement. Applications of these procedures are reviewed including on-line troubleshooting methods to assure quality in manufacturing. *Prerequisite: IE 611.* Also listed as MN 612.

### **IE 618 Inventory Models\*** 2½:0:0:3

Study of inventory systems. Deterministic and probabilistic models. Fixed versus variable reorder intervals. Dynamic and multistage models. Statistical forecasting of demands and lead times. Control of dynamic inventory systems with lead times. *Prerequisites: MA 561 and either IE 627 or MA 813.*

### **IE 619 Production Planning and Control** 2½:0:0:3

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 627 or MA 813.*

### **IE 620 Project Planning and Control** 2½:0:0:3

Network planning techniques for project management and resource allocation. Emphasis on PERT, CPM, and probabilistic generalized network. 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.* Also listed under MG 810 and CE 828.

### **IE 621 Facility Planning and Design\*** 2½:0:0:3

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 606 or permission of instructor and either IE 627 or MA 813.*

### **IE 627 Operations Research: Deterministic Models\*** 2½:0:0:3

Development of mathematical models for solving decision problems of deterministic nature. Classical optimization, Lagrange multipliers, linear programming, transportation method, network procedures, games. Dynamic programming. (Not open to students who have taken IE 327 or equivalent.) *Prerequisite: Calculus.*

### **IE 628 Operation Research: Stochastic Models\*** 2½:0:0:3

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. *Prerequisite: MA 561.*

### **IE 645 Productivity Management** 2½:0:0:3

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 645.

### **IE 650 Queuing Systems I** 2½:0:0:3

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 561.*

### **IE 682 System Simulation, with Factory and Other Applications** 2½:0:0:3

Modeling and simulation of complex industrial, commercial, and service systems, such as factories and hospitals. Students develop, run and experiment with several simulation models using different software packages. *Prerequisites: knowledge of computer programming and MA 561 or equivalent.*

### **IE 685 System Reliability\*** 2½:0:0:3

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: EI 531 or MA 561 or equivalent.*

### **IE 765 Human Factors in Engineering Design\*** 2:1:0:3

Study of research techniques that yield information important in man-machine systems design. Man's learning, problem-solving, physiological and information processing capacities, performance under various environmental conditions. *Prerequisite: SS 189, or permission of instructor.*

### **IE 775 Industrial Safety Engineering\*** 2½:0:0:3

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.

### **IE 776 Manufacturing Resource Planning\*** 2½:0:0:3

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 619, or instructor's permission, knowledge of computer programming.*

**IE 785 Computer Integrated Manufacturing Systems (CIMS)**  
2 1/2:0:0:3

Introduction to the basic concepts of manufacturing complex products with complex processes. This type of manufacturing implies a strong use of and reliance on computer and data processing technologies. All aspects relative to product and process: planning, design, manufacturing and shipping will be addressed from a variety of perspectives. Elements of the production system and interfaces between these elements will be defined. Methods and techniques for studying, managing, and optimizing manufacturing and engineering productivity will be explored. *Prerequisite: SS 189, or permission of instructor. Also listed as MN 785*

**IE 788 Manufacturing Systems Engineering**  
2 1/2:0:0:3

Contemporary techniques for product design and manufacturing. Financials of the manufacturing firm, quality and reliability, Taguchi's methods for design of products and processes, scale-up and partitioning, design of experiments, characterization of manufacturing flows, and descriptions of modern manufacturing methods such as JIT/TQC, pull and synchronized manufacturing. Cultural factors associated with the introduction of these new techniques. Financial and performance metrics are developed for each new process. Applications are illustrated by case studies of successes and disasters. *Also listed as MN 788*

**IE 792 Design for Manufacturability (DFM)**  
2 1/2:0:0:3

Concepts and techniques involved in designing products so that they can be economically manufactured, functionally sound and of high quality. Technical guidelines for utilizing several manufacturing processes effectively, managerial and organizational approaches and case studies of products that were successfully designed or redesigned for easy manufacture. Particular attention is given to designing for easy assembly, both robotics and manual, and to the effective use

of plastics to reduce the cost of manufactured products. Students are given some simple projects so that they can experience the procedure first hand. *Also listed as MN 792*

**IE 911-912 Selected Topics in IE & OR I, II\***  
each 2 1/2:0:0:3

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 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 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 requested by department. Registration and degree credit beyond first six units require separate approval. *Prerequisite: degree status and approval of supervising professor, adviser and department head.*

**FACULTY**

**William R. McShane, P.E.**, Professor of Industrial and System Engineering Head, Department of Mechanical 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)).  
*Quality control, controls and simulation, engineering economics, laboratory development.*

**Charles W. Hoover, Jr.**, Professor of Manufacturing Engineering  
B.E.M.E., Yale University; B.S.E.E., Massachusetts Institute of Technology; M.S., Ph.D., Yale University.  
*Physical Design; manufacturing processes; electronic device assembly.*

**Charles A. Kelly**, Industry Professor of Manufacturing and Industrial Engineering  
B.S., Syracuse University; M.S., University of Detroit  
*Work methods, design of manufacturing systems, computer aided engineering.*

**Nathan Levine**, Industry Professor of Manufacturing Engineering  
B.Sc., Massachusetts Institute of Technology; M.Sc, University of Illinois; Ph.D, University of Illinois  
*Quality, robust design, design of experiments, effecting cultural change, and organizational transformation*

**Anthony P. Tzes**, Assistant Professor of Mechanical Engineering  
B.S.E.E., University of Greece; M.S.E.E., Ph.D., Ohio State University  
*Robotics, adaptive control, computer integrated manufacturing, artificial intelligence, neural networks.*

**Jerome I. Barancik**, Visiting Research Professor of Industrial Engineering  
B.S. Roosevelt University  
M.S. University of Massachusetts at Lowell  
Sc.D. University of Pittsburgh  
*Information systems, occupational safety & health, engineering & epidemiologic systems, transportation & systems safety engineering.*

**Robert E. Hall**, Visiting Research Professor of Industrial Engineering  
B.S.E.S., Hofstra University; M.S.M.E., State University of New York at Stony Brook.  
*Thermal hydraulic engineering, risk & reliability analysis, nuclear/power engineering, human factors.*

**EMERITUS FACULTY**

**Walter Helly**, Professor Emeritus  
B.A., Cornell University; M.S.  
University of Illinois; Ph.D.,  
Massachusetts Institute of Technology

**Joachim J. Weindling**, P.E., Professor  
Emeritus  
B.M.E., City College of New York;  
M.S., Ph.D., Columbia University;  
Professional Engineer (N.Y., P.A.)

**John H.K. Kao**, Professor Emeritus  
B.S., National Central University  
(China); M.S., Eng. Sci.D., Columbia  
University

**Ravinder Nanda**, Associate Professor  
Emeritus  
B.Sc., Banaras Hindu University  
(India); M.S., Ph.D., University of  
Illinois

# INFORMATION SYSTEMS ENGINEERING

The School of Electrical Engineering and Computer Science in conjunction with New York State's Center for Advanced Technology in Telecommunications (CATT) offers a Master of Science degree program in Information Systems Engineering.

Polytechnic started this masters degree program in 1987 with the express purpose of providing education for industry people faced with the challenges and opportunities of integrating computers and communication systems.

The development of the curriculum was sponsored by CATT at the 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 to

- (i) monitor the effectiveness of the program,
- (ii) help keep the detailed course syllabi current, and
- (iii) propose changes in the program in light of experience.

The philosophy of the program is to provide rigorous education in the component disciplines of computers and telecommunications with emphasis on the unified field of information systems engineering. The focus is the application of theoretical insights to practical problems. The program combines courses from electrical engineering, computer science, social science and management.

Students are experienced, working professionals in telecommunications or computing with two or more years of working experience.

Classes meet every other week, all day, Friday and Saturday, at Polytechnic's Westchester Graduate Center in Hawthorne, New York. Breakfast, lunch, and coffee breaks are provided. All classes are video-

taped with the tapes made available for viewing on campus or at home.

An all-inclusive fee covers tuition and fees, text books and other educational material, special tutorials and lectures, meals on class days, and access to 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, probability and a programming language. Furthermore, applicants must have a minimum of two years work experience in the field of telecommunications and/or computing and must have employer support.

Applications for admission are accepted throughout the year, but admission is for fall semesters only. Because enrollment is limited, early application is strongly recommended.

## DEGREE REQUIREMENTS AND CURRICULUM

The general requirements for Master of Science Degree are stated elsewhere in this catalog.

The curriculum consists of 13 courses (39 academic units) which are offered in a structured program over a two-year period. There are no elective courses in this program.

The courses in the curriculum are:

FALL

*First Semester*

CS 613 *Computer Architecture*  
EL 635 *Principles of Communications Networks*  
CS 676 *Mathematical Techniques for Information Systems*

SPRING

*Second Semester*

CS 623 *Operating Systems*  
EL 735 *Communication Networks I*  
CS 606 *Software Engineering*

FALL

*Third Semester*

EL 736 *Communications Networks II*  
MG 820 *Project Management*  
CS 907 *Human Factors in Information Systems*

SPRING

*Fourth Semester*

CS 630 *Input and Output Systems*  
MG 654 *Economics of Information Systems*  
CS 608 *Principles of Data Base Systems*

During the second year of study each student completes an independent, applied research project of practical importance to his/her employer. The purpose of the project is to give students an opportunity to apply and integrate the subjects taught in the program by working directly with a faculty member.

CS 996 *Advanced Project in Computer Science*

## COURSE DESCRIPTIONS

For course descriptions, refer to the appropriate other sections of this catalog (Management, Electrical Engineering, Computer Science).

<b>CS 613 Computer Architecture I</b>	<i>3 units</i>
<b>EL 635 Principles of Communication Networks</b>	<i>3 units</i>
<b>CS 676 Mathematical Techniques for Information Systems</b>	<i>3 units</i>
<b>CS 623 Operating Systems I</b>	<i>3 units</i>
<b>EL 735 Communication Networks I</b>	
<b>CS 606 Software Engineering I</b>	<i>3 units</i>
<b>EL 736 Communication Networks II</b>	<i>3 units</i>
<b>MG 820 Project Management</b>	<i>3 units</i>
<b>CS 907 Human Factors in Information Systems</b>	<i>3 units</i>
<b>CS 630 Input and Output Systems</b>	<i>3 units</i>
<b>MG 654 Economics of Information Systems</b>	<i>3 units</i>
<b>CS 608 Principles of Database Systems</b>	<i>3 units</i>
<b>CS 996 Advanced Project in Computer Science</b>	<i>3 units</i>

## FACULTY

**Robert R. Boorstyn**, Professor of Electrical Engineering and Computer Science; B.E.E., CCNY; M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Telecommunications*

**Shivendra Panwar**, Associate Professor of Electrical Engineering  
T. Tech., Indian Institute of Technology; M.S., Ph.D., University of Massachusetts  
*Communication networks.*

**Richard Van Slyke**, Professor of Electrical Engineering and Computer Science; B.S., Stanford University; Ph.D., University of California at Berkeley  
*Computer communications, telecommunications.*

## INDUSTRY PROFESSORS

**Robert J. Flynn**, Industry Professor of Computer Science  
B.S. (Physics), Manhattan College; M.S. (Math), Ph.D. (Math), Polytechnic Institute of Brooklyn  
*Computer architecture and operating systems.*

**Barry Jones**, Industry Professor of Electrical Engineering and Computer Science; B.S., Cooper Union; M.S., Marist College  
*Electromechanical systems, real-time computer systems*

**Nancy J. Needham**, Industry Professor of Management  
Academic Director, Telecommunications and Computing Management program  
B.A., Wellesley College; M.B.A., D.B.A., Harvard University  
*International telecommunications and financial services.*

## ADJUNCT FACULTY

**Aaron Kershenbaum**, Adjunct Professor of Computer Science  
B.S., M.S., Polytechnic Institute of Brooklyn; Ph.D., Polytechnic Institute of New York; *Computer communications and algorithms.*

**Charles J. Bontempo**, Adjunct Professor of Computer Science  
B.A., M.A., University of Maryland  
*Distributed Data Bases*

**Robert Cahn**, Adjunct Professor of Computer Science, S.B. University of Chicago, Ph.D, Yale  
*Computer communications and algorithms.*

**Mon Song Chen**, Adjunct Professor of Computer Science; B.S., National Taiwan University; M.S., University of Washington; Ph.D., Polytechnic University

**E. Hart Rasmussen**, Adjunct Professor of Management; Director, Management Programs, Westchester Center; B.S., M.S., Technical University of Denmark  
*Project management.*

# MANAGEMENT

The Department of Management offers five graduate degrees:

- Master of Science in Management
- Master of Science in Organizational Behavior
- Master of Science in Operations Management\*
- Master of Science in Telecommunications and Computing Management\*
- Master of Science in Management of Technology\*

\* see separate program listing

## THE MASTER OF SCIENCE PROGRAM IN MANAGEMENT

The master of science in management degree (MSM) is recognized, along with the master of business administration (MBA), by the Graduate Management Admission Council as graduate professional management degrees. Polytechnic's MSM is designed to prepare working professionals for increasing responsibility in management positions. The 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.

These management skills can be applied in a broad range of professional settings both in the private and the public sector; in labor-intensive and in capital-intensive industries; in production-oriented and in service-oriented activities and in traditional as well as in high-technology environments.

Polytechnic's graduate program in management takes a pragmatic, results-oriented approach that emphasizes management of technology and people, production management, and strategic planning to achieve long term productivity

and profitability. Traditional subjects such as accounting, economics, finance, and marketing are taught, not as special areas of expertise, but as basic tools for managerial decision-making.

After completing the core courses, degree candidates build further managerial skills in their choice of 5 concentrations:

- Construction Management
- Human Resource Management
- Information Management
- Quality and Productivity Management
- Technology Management

The program concludes with a course in Business Policy and Strategy which integrates the functional disciplines studied throughout the program. Through case studies the students acquire an understanding of top management's perspective, how organizations set goals, establish policies, and implement strategies to gain competitive advantage.

Polytechnic's students are working professionals, including engineers and scientists with managerial responsibility. Small classes (averaging 15 or fewer students) enable the students to receive close individual attention from the faculty.

**Admission** — Criteria for admission include having a bachelor's degree with at least a B average from an accredited college or university and demonstrated evidence of motivation, maturity, and the ability to benefit from and contribute to professional graduate studies. An applicant who does not meet all the criteria may be admitted as a non-degree student with the opportunity subsequently to become a degree candidate. Satisfactory scores on the Graduate Management Admission Test (GMAT) or an acceptable equivalent test may be used as support for admission to degree studies.

**Degree Requirements** — The MSM requires completion of a minimum of 12 courses, or 36 units, with a B average or

better. Students who lack prerequisites may be required to take up to 4 additional basic courses, or 12 units. Transfer credits of 9 units may be granted for graduate courses taken previously, as evaluated by an adviser.

## THE CURRICULUM

**1. Basic and Core Courses.** The basic and core courses provide a management base upon which students can build a variety of specializations within the degree programs. These courses provide intensive introductions to the several disciplines required of professional managers. Students who have taken these courses elsewhere or previously at Polytechnic, or who have had equivalent experience, may be excused from them. However, students are required to complete a minimum of 36 units (12 courses) at the 600 level or above.

### 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*
- MG 608 *Managerial Economics and the Economic Environment*

**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 courses 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.

## MANAGEMENT

**4. Strategic Management (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 a minimum 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 an adviser's approval in any concentration areas.

#### Construction Management

##### Select four:

- MG 631 *Organization Theory and Design*
- MG 664 *Management and the Legal System*
- MG 810 *Project Planning and Control*
- MG 820 *Project Assessment & Management*
- MG 825 *Construction Administration*
- MG 826 *Construction Estimates and Costs*
- MG 827 *Specifications and Contracts*
- MG 830 *Formulation and Analysis of Public Works*

#### Human Resource Management

##### Required:

- MG 612 *Human Resource Management*
- MG 633 *Research Methods*

##### Electives — Select two:

- MG 611 *Career Management*
- MG 613 *Labor Relations*
- MG 616 *Job and Workplace Design*
- MG 617 *Performance Measurement and Reward Systems*
- 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 *Organization Theory and Design*

#### Information Management

##### Select four:

- MG 612 *Human Resource Management*
- MG 626 *Human Resource Information Systems*
- MG 650 *Management of the Information Function*
- MG 654 *Economics of Information Systems*

- MG 664 *Management and the Legal System*
- MG 716 *Commercial Data Processing Systems and Design*
- MG 737 *Analysis and Design of Management Information Systems*
- MG 810 *Project Planning and Control*
- MG 820 *Project Assessment & Management*
- CS 603 *Design and Analysis of Algorithms I*
- CS 681 *Information Privacy and Security*

#### Quality and Productivity Management

##### Required:

- MG 630 *Operations Management*
- MG 635 *Introduction to Total Quality Management*

##### Select two:

- MG 612 *Human Resource Management*
- MG 624 *Organization Development*
- MG 705 *Managerial Planning Process*
- MG 850 *Cost Systems*
- MG 868 *Strategic Management of Productivity*

#### Technology Management

##### Required:

- MG 865 *Managing the Innovative Process*
- MG 866 *Technology, Management and Policy*

##### Select two:

- MG 627 *Human Resources and Technological Change*
- MG 630 *Operations Management*
- MG 664 *Management and the Legal System*
- MG 672 *Technological Forecasting*
- MG 820 *Project Assessment & Management*
- MG 864 *Product Planning*
- MG 867 *Technology Strategy*
- MG 868 *Strategic Management of Productivity*

## MASTER OF SCIENCE IN ORGANIZATIONAL BEHAVIOR

**Program** — A graduate evening program requiring 36 units of course-work is offered to students who wish to specialize in organizational behavior, a field concerned with solving human problems in modern organizations. The program includes both theoretical and practical courses relevant to organizational behavior and effective management of people.

**Admission** — Applicants must meet the basic admission requirements of the graduate programs in Management. Students who have not completed an undergraduate course in statistics will be required to enroll in MG 505, Statistical Analysis. Those with little or no background in computers must make up the deficiency by enrolling in MG 502, Computers in Management. These courses are in addition to degree requirements.

### THE CURRICULUM

**1. Required Core Courses** - An organizational behavior base consists of three core courses upon which the student can build a specialization within the degree program. Core courses provide an introduction to several areas basic to organizational behavior. Students who have previously completed courses in any of these areas, may be excused from taking them by presenting proof of competence and receiving waivers from the Program Director. Other courses must then be substituted with permission of the Program Director.

##### The core courses are:

- MG 601 *Organizational Behavior*
- MG 631 *Organization Theory and Design*
- MG 633 *Research Methods*

**2. Areas of Concentration** - Students must choose an area of concentration, consisting of six courses. These may be one of three concentrations listed below or, with adviser's approval, may consist of a series of six courses designed to meet students' special needs.

Courses in each of the three areas of concentration are shown below:

#### Management of Change

##### Required:

- MG 624 *Organization Development*
- MG 627 *Human resources and Technological Change*

##### Select four:

- MG 611 *Career Management*
- MG 614 *Conflict Management*
- MG 616 *Job and Workplace Design*
- MG 625 *Seminar in Career Management*
- MG 635 *Introduction to Total Quality Management*

## Human Resource Management

### Required:

- MG 612 *Human Resource Management*  
 MG 617 *Performance Measurement and Reward Systems*

### Select four:

- MG 611 *Career Management*  
 MG 622 *Personnel Psychology*  
 MG 625 *Seminar in Career Management*  
 MG 626 *Human Resource Information Systems*  
 MG 635 *Introduction to Total Quality Management*

## Training and Development

### Required:

- MG 623 *Training in Organizations*  
 MG 624 *Organization Development*

### Select four:

- MG 611 *Career Management*  
 MG 612 *Human Resource Management*  
 MG 625 *Seminar in Career Management*  
 MG 627 *Human Resources and Technological Change*  
 MG 635 *Introduction to Total Quality Management*

**3. Free Electives** - Two appropriate graduate courses may be chosen from any program at Polytechnic with adviser's consent.

**4. Research Projects** - MG 634 Applied Research Methods

All students are required to submit an independent research project. In special cases, MG 997, a thesis for degree of master of science, may be substituted for students who wish to produce a major research project.

## CERTIFICATE PROGRAMS

The Department of Management offers several certificate programs designed for professionals with work experience. Applicants for certificate programs must hold bachelor's degrees. A certificate program requires five courses, which are selected according to individual needs. On completion of a sequence with an average grade of B or better, students are issued certificates. Those who choose to work towards the

master's degree are able to apply all courses taken toward a certificate, upon admission, toward fulfillment of a degree program. Additional information may be obtained from the department.

**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:

- Construction Management
- Human Resource Management
- Information Management
- Quality and Productivity Management
- Operations Management
- 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 training and development to management of change.

## UNDERGRADUATE COURSES

### MG 300 Management Process

3:0:0:3

Introductory management course for undergraduates. Primary focus is the management process: planning, organizing, staffing, controlling, directing and decision making. Attention is given to the roles of various disciplines within management as well as to the traditional business functions of marketing, accounting, finance, production, engineering, research and development. **Also listed under SS 270**

### MG 301 Organizational Behavior

3:0:0:3

Study of human behavior in organizational settings. Emphasis on motivation,

informal and formal group dynamics; interpersonal relationships; supervision; leadership; communication theory; attitude and job satisfaction; work-stress; career development; creativity. Analyses of organizational behavior problems by case studies and simulated situations. **Also listed under SS 299**

### MG 304 Accounting Fundamentals

3:0:0:3

Managerial approaches to problems of cost determination and analysis. Job order, process and standard cost systems. Analysis of indirect manufacturing expenses, preparation and analysis of balance sheets, income and manufacturing statements. Relations between accounting and engineering functions.

### MG 305 Foundations of Business Systems

3:0:0:3

This course provides the student with a systems perspective on the specification, development, implementation, and maintenance of organizational information technology. *Prerequisite MG 300. Also listed under SS 275.*

### MG 306 Financial Management

3:0:0:3

This survey course in financial management provides the student with an understanding of various financial reports and instruments. An appreciation will also be gained for the use of techniques — such as financial ratio analysis — for assessing the firm's overall productivity and health. Financial planning and analysis, and capital budgeting, will also be treated.

## GRADUATE COURSES

### MG 502 Computers in Management

2 1/2:0:0:3

Computer literacy for management problem-solving, information systems, computer technology, software and vocabulary. Survey of software, compilers, interpreters, assemblers and language important to managers. Examples and cases of decision-support systems and their operation.

## MANAGEMENT

### **MG 503 Economic Environment of Management** 2½:0:0:3

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** 2½:0:0:3

Aspects of accounting of practical use to the manager. Stress on understanding of financial statements rather than on book-keeping procedures. Internal management usage of accounting data: job orders, process and standard costing; relations among accounting, economic and financial perspectives.

### **MG 505 Statistical Analysis** 2½:0:0:3

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** 2½:0:0:3

A basic course on modern management methods covering planning, organization, control, motivation and leadership. The course also deals with the role of information systems and other critical areas such as ethics, social responsibility and global management.

### **MG 601 Organizational Behavior** 2½:0:0:3

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 culture, structure and

design, impact of technology, career development.

### **MG 606 Managerial Finance** 2½:0:0:3

Analyses of principles and practices of the finance function and its application in organizations. Survey of uses of financial instruments, sources and uses of short- and long-term funds, capital budgeting under certainty and uncertainty; cost of capital and dividend policy; working capital management. *Prerequisite: MG 504 or equivalent.*

### **MG 607 Marketing** 2½:0:0:3

Marketing concepts, processes and institutions: positioning, segmentation, product life cycles. Integration of marketing with new product planning, design and development. Strategies for technology based products, services, and processes. Market research, consumer behavior, advertising, promotion and sales. The special character of industrial and governmental markets. *Co/Prerequisite: MG 503.*

### **MG 608 Managerial Economics and the Economic Environment** 2½:0:0:3

Microeconomic analysis and the macroeconomic environment for managers. Economic basis for managerial decisions in production, investment and technology strategy. Economics of the firm, business cycles, economic growth, international trade, financial institutions, currency systems. The economics of innovation and entrepreneurial activity. The role of technology in economic growth and in international competition. *Prerequisite: MG 503.*

### **MG 611 Career Management** 2½:0:0:3

An examination of careers from the perspectives of both management and individuals, including career stage models, organizational entry, career pathing, mid-career crisis, career change, continuing education and retraining, professional obsolescence, career re-entry, job loss and underemployment. Emphasis on career assessment exercises for self evaluation. *Prerequisite: MG 601 or permission of instructor.*

### **MG 612 Human Resource Management** 2½:0:0:3

Personnel functions are investigated from the perspectives of individual managers and the total organization. Topics include work force characteristics, recruitment and development, performance evaluation and rewards, effects of legislation and the changing labor force. *Prerequisite: MG 601 or permission of instructor.*

### **MG 613 Labor Relations** 2½:0:0:3

Policies and philosophies of management, organized labor and government with regard to solution of labor problems. Evaluation of industrial relations problems, particularly those of collective bargaining, emphasizing interrelationships with social, economic and legal trends. *Co/Prerequisite: MG 601 or permission of instructor.*

### **MG 614 Conflict Management** 2½:0:0:3

This course investigates the nature and meaning of conflict in professional and technical organizations as well as society. Analysis of the design of conflict avoidance and mitigation program. Alternative Dispute Resolution modalities are presented and demonstrated. Students design effective programs and class analysis. *Prerequisite: MG 601 or permission of instructor.*

### **MG 616 Job and Workplace Design** 2½:0:0:3

An examination of the interaction among individual, job design and work environment characteristics. Topics include work analysis; task and workspace design; impact on communication; job satisfaction; motivation and productivity; job and work environment redesign; socio-technical design approaches; emerging role of artificial intelligence. *Prerequisite: MG 601 or permission of instructor.*

### **MG 617 Performance Measurement and Reward Systems** 2½:0:0:3

An introduction to practical approaches in the establishment of a performance appraisal system that includes theoretical

and applied issues. Reasons for implementing a performance appraisal system in organizations are addressed. Other topics include coaching, feedback, and performance evaluation. The role of compensation benefits and other rewards in attracting, retaining and motivating employees. *Prerequisite: MG 601 or permission of instructor.*

**MG 622 Personnel Psychology** 2/1:0:0:3

Examination of theory, research and practice concerning individual differences relating to organizational behavior with emphasis on the personnel selection process, measurement of predictors, criteria for validation and decision-making strategies. *Prerequisites: MG 601 and MG 505 or permission of instructor.*

**MG 623 Training in Organizations** 2/1:0:0:3

The roles of training in organizations, focusing on department and line managers. Subjects addressed include needs analysis, preparation of employees for jobs, management development, training program design, evaluation and employee obsolescence and retraining. *Prerequisite: MG 601 or permission of instructor.*

**MG 624 Organization Development** 2/1:0:0:3

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** 2/1:0:0:3

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 are 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** 2/1:0:0:3

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 678.**

**MG 627 Human Resources and Technological Change** 2/1:0:0:3

Examination of the impact of technological changes on human resources and their effective management in manufacturing and service organizations. Focuses on ways to introduce change and covers leadership, education, and training techniques for new environments. *Prerequisite: MG 601 or permission of instructor.*

**MG 630 Operations Management** 2/1:0:0:3

Analytical techniques for designing and operating production and service systems, including facility layouts and locations, capacity planning, job sequencing, inventory control, and quality control. Introductory linear programming and other formal methods. Cases and PC usage.

**MG 631 Organization Theory and Design** 2/1:0:0:3

Analysis of theories of large-scale organizations focusing on their structure and design. Includes characteristics of bureaucracy, adhocery, suboptimization, human dynamics and informal systems, influence and control systems, planned change. Examination of both formal and informal organizations through research and case studies. *Prerequisite: MG 601 or permission of instructor.*

**MG 633 Research Methods** 2/1:0:0:3

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 proposals are developed. *Prerequisite: MG 505 and MG 601 or permission of instructor.*

**MG 634 Applied Research Methods** 2/1:0:0:3

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 635 Introduction to Total Quality Management** 2/1:0:0:3

Total Quality Management (TQM) proposes that organizations take a holistic approach to quality. TQM proponents claim that designing quality into products — rather than simply trying to “inspect” quality into them — and effectively organizing and motivating the workforce are the main factors contributing to low production costs, and ensuring a perception of high quality on the part of the consumer. The effectiveness of TQM is examined using articles and case studies.

**MG 650 Management of the Information Function** 2/1:0:0:3

This course focuses on the corporate MIS Department and the role of the Chief Information Officer. It deals with such organizational and human resource matters as how the MIS activity itself should be structured and organized in different corporate and MIS environments. It also covers the operational aspects of running a MIS activity.

**MG 654 Economics of Information Systems** 2/1:0:0:3

This course focuses on the more detailed functions of selecting equipment, systems and software. It starts with the development of the RFP and goes on through the various phases of developing selection criteria, benchmarking, cost benefit analyses, service options and financing options. It covers computers, software and telecommunications.

## MANAGEMENT

### **MG 664 Management and the Legal System** 2½:0:0:3

Impacts of the legal system on corporate strategy, managerial decisions and planning processes. Issues covered include: protection of intellectual and technological properties; consumer, contract, commercial laws; employer liability; negligence and risk-management from legal and corporate viewpoints, and constitutional and regulatory aspects of conducting business.

### **MG 671 Business and Economic Forecasting** 2½:0:0:3

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.*

### **MG 672 Technological Forecasting** 2½:0:0:3

Covers the role of technological forecasting in strategic planning, including assessment of internal technologies and identification of external threats. Presents tools and techniques for anticipation and dealing with technological change.

### **MG 700 New Enterprise and Small Business Management** 2½:0:0:3

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. *Prerequisite: Advanced Standing.*

### **MG 705 Managerial Planning Processes** 2½:0:0:3

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 716 Commercial Data Processing Systems Design** 2½:0:0:3

The course deals with how to design a selected application from inception through analysis, design implementation and evaluation. It reviews available tools and techniques for the various design phases.

### **MG 737 Analysis and Design of Management Information Systems** 2½:0:0:3

This course focuses on the strategic use of information systems in business. It deals with the more global issues of how information technology can effectively support the strategic plans and mission of a business, including application portfolio, information architecture, longer term planning for information systems and the integration of MIS planning with corporate planning activity. It also covers the role of new techniques such as artificial intelligence.

### **MG 810 Project Planning and Control** 2½:0:0:3

Network planning techniques for project management and resource allocation. Emphasis on PERT, LOB, CPM and probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Network development, computer adaptation, progress reports and project monitoring. **Also listed under IE 620 and CE 828.**

### **MG 820 Project Assessment & Management** 2½:0:0:3

Management of technology-based projects ranging from individual research and development to large-scale and complex technological systems. Feasibility and risk analyses. Project selection and portfolio optimization. Functional and administrative structures, coordination and scheduling of activities, personnel planning, negotiations and contracts, cost estimation, capital budgeting, cost controls, effective matrix management. **Also listed under CE 820.**

### **MG 825 Construction Administration** 2½:0:0:3

Management techniques of construction are discussed in relation to alternate means of project execution. Organizational structures, management systems, and controls are examined from the points of view of owners, the constructors, and the professional construction managers. **Also listed under CE 825.**

### **MG 826 Construction Estimates and Costs** 2½:0:0:3

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. **Also listed under CE 826.**

### **MG 827 Specifications and Contracts** 2½:0:0:3

Principles of contract law applied to construction; legal problems in preparing and administering construction contracts. **Also listed under CE 827.**

### **MG 864 Product Planning** 2½:0:0:3

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 sequentially: initial search; preliminary evaluation; organizing, etc. Financial aspects of product development. *Prerequisites: MG 600 and MG 607.*

### **MG 865 Managing the Innovative Process** 2½:0:0:3

Managing research, development, and engineering; and technology transitions. Planning, controlling, and evaluating R&D projects. Integrating R&D management with corporate strategy, new product development, marketing, production, and finance. Technology forecasting and applications assessment. Communication of technical information within the corporation; corporate acquisition of technical knowledge. *Prerequisite: MG 600.*

**MG 866 Management, Technology and Policy** 2 1/2:0:0:3

Technology and the Manager. Technology as an element of corporate strategy. Moving into new technologies: timing and choice. Technological entrepreneurship: start-up companies; internal venturing; diversification strategies. Strategic alternatives in uncertain technological environments. Technology acquisition through strategic alliances. Global dimensions of technological markets. Government roles in directing technological innovation and development.

**MG 867 Technology Strategy** 2 1/2:0:0:3

Technology as a strategic variable. Entrepreneurial high-tech strategies: from start-up companies to large corporations. Introducing new technologies: timing and choice. Strategic alliances. The changing role of industrial R&D in technology strategy. Technology strategy for global markets. Japanese and European comparisons: Legal aspects of multinational transactions, intellectual property and technology transfer.

**MG 868 Strategic Management of Productivity** 2 1/2:0:0:3

U.S. productivity relative to that of its trading partners and competitors in international trade. Current controversies and their theoretical and empirical foundations. Efforts to define long-term, strategic roles for productivity in manufacturing and in providing services. Reassessment of the strategic function of the management of production. *Prerequisite: Advanced standing.*

**MG 969 Operations Strategy** 2 1/2:0:0:3

Operations Strategy is an advanced topics case oriented course which relates the firm's business strategy to its long-term commitments in terms of the productive capacity of operations, inventory control, quality control, product and process design, and human resources development. This is unlike operations management courses, which usually focus on short-term decisions within these areas.

**MG 970 Strategic Management** 2 1/2:0:0:3

Strategic thinking and practice from the general management perspective The formulation and implementation of strategy and strategic planning in the organization. Strategic portfolios and other planning systems. The analysis of competition within and industry and of the elements of value that contribute to competitive advantage. Strategic issues for international business and multinational corporations. *Prerequisite: Advanced standing.*

**MG 975 Selected Topics in Management** 2 1/2:0:0:3

Current topics in various fields analyzed and discussed. *Prerequisites: Advanced standing and permission of instructor.*

**MG 976-977 Readings in Management** --:--:3

Directed individual study of supervised readings in advanced areas of management. *Prerequisite: permission of dean.*

**MG 985 Selected Topics in Organizational Behavior** 2 1/2:0:0:3

Discussion and analysis of current topics in organizational behavior. *Prerequisites: Advanced standing and permission of instructor.*

**MG 986-987 Readings In Organizational Behavior** --:--:3

Directed individual study or supervised readings in advanced areas of organizational behavior. *Prerequisite: permission of dean.*

**MG 997 Thesis for Degree of Master of Science** --:--:3

Original investigation in topic chosen by student. Conferences and progress reports required during work, and final written report required at completion; oral examination may be requested by department. Registration and degree credit beyond first six units require separate approval. *Prerequisites: degree status and approval of supervising professor, adviser and department director.*

**INFREQUENTLY OFFERED COURSES**

**MG 619 Employee Scheduling**

**MG 830 Formulation and Analysis of Public Works Projects**  
Also listed under CE 781

**MG 850 Cost Systems**  
*Prerequisite: MG 504.*

**MG 860 Financial Planning, Internal Reporting and Operation Control**  
*Prerequisites: MG 504 and MG 606.*

**MG 863 Market Research**  
*Prerequisite: MG 607.*

**MG 871 Manufacturing Strategies**  
Also listed under MN 622.

**FACULTY**

**Ralph E. Weindling**, Head Management Department. Industry Professor of Management. B.S., University of Pennsylvania; M.B.A., Harvard University  
*General management, corporate strategy, management information systems*

**A. George Schillinger**, Professor of Management and Program Director, Management of Technology B.E.E., City College of New York; M.S., Eng. Sc.D., Columbia University  
*General management, technology management, corporate strategy*

**Nancy Needham**, Industry Professor of Management, Associate Director of CATT B.A., Wellesley College; M.B.A., D.B.A., Harvard University  
*International telecommunications and financial services*

## MANAGEMENT

**Harold G. Kaufman**, Associate Professor of Management and Program Director, Organizational Behavior B.M.E., Cooper Union; M.I.E., Ph.D., New York University

*Career management, science and engineering manpower obsolescence and continuing education*

**Byron David**, Assistant Professor and Program Director, Operations Management

B.A., Queens College of CUNY; M.S., Polytechnic Institute of New York; M.B.A. and Ph.D., Baruch College, CUNY  
*Strategy and productivity management*

**E. Hart Rasmussen**, Adjunct Professor; Program Director, Westchester Graduate Center; Licensed Professional Engineer in New York and New Jersey;

B.S., M.S. (Chem.Eng.) Polytechnic University of Denmark  
*Project management, control systems*

### ADJUNCT FACULTY

**Seymour Kaplan**, Adjunct Professor B.S., Newark College of Engineering; M.S., Ph.D., New York University

**Kathleen, MacDonald**, Adjunct Professor B.S., Columbia University; M.A., Columbia University Teachers College; MBA Golden Gate University; Ed.D., Columbia University Teachers College

**Sylvester Marino**, Adjunct Professor B.S., Fordham University; MBA, St. John's University; Ed.M., Ed.D., Columbia University Teachers College

**Anthony J. Wiener**, Adjunct Professor A.B., J.D., Harvard University

**Stanley S. Willing**, Adjunct Professor B.A., M.A., Ed.D., New York University

**Michael Cortegiano**, Adjunct Associate Professor B.S., Fairfield University

**Edward Greenbaum**, Adjunct Associate Professor B.S., Arnold College; M.A., New York University; M.S., Cornell University

**Donald Harris**, Adjunct Associate Professor B.A., Ohio Wesleyan University; M.B.A., New York University; Ph.D., Columbia University

**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*

**Joel Joseph**, Adjunct Associate Professor B.A., Yale University; J.D., Hofstra Law School

**Mark Kurman**, Adjunct Associate Professor B.A., New York University; M.A., Ph.D., Bowling Green State University

**Daniel E. Lupton**, Adjunct Associate Professor B.A., M.Ed., S.T.L., Loyola University; M.A., Indiana State University; M.B.A., Ph.D., University of Chicago

**Patrick McNelis**, Adjunct Associate Professor B.E.E., Manhattan College; M.S.E.E., Polytechnic Institute of New York

**Ary Mossiman**, Adjunct Associate Professor B.S., Pratt Institute; M.S., Long Island University; M.S.M., Polytechnic Institute of New York

**Charles W. Monroe**, Adjunct Associate Professor B.S., Pratt Institute; M.S., Massachusetts Institute of Technology; C.Sci.D., New York University.

**William Raichle**, Adjunct Associate Professor B.S., St. Francis College; M.S., Shippensburg State University; Ph.D., New York University

**Robert Schiffer**, Adjunct Associate Professor B.S., M.B.A., Adelphi University

**Mark B. Sokol**, Adjunct Associate Professor B.A., Queens College; M.A., Ph.D., University of Maryland, College Park

**Arthur R. Szeglin**, Adjunct Associate Professor B.S., M.S., Polytechnic Institute of Brooklyn, M.A., Ph.D., Hofstra University

**Kenneth Walden**, Adjunct Associate Professor B.S., City College of New York; M.S., New York Institute of Technology

**Traci Berliner**, Adjunct Assistant Professor B.A., S.U.N.Y. at Binghamton; M.S., Rensselaer Polytechnic Institute; Ph.D., Stevens Institute of Technology

**Peter M. Kash**, Adjunct Assistant Professor B.S., S.U.N.Y. at Binghamton; M.B.A., Pace University

**David Krautheimer**, Adjunct Assistant Professor B.S.E., New York Institute of Technology; M.S., C.W. Post

**Susan Meyer**, Adjunct Assistant Professor B.A., S.U.N.Y. at Albany; M.A., New York University; Ed.D., Columbia University

# MANAGEMENT OF TECHNOLOGY

The Department of Management offers a Master of Science executive program in the Management of Technology.

Technology-intensive corporations need a capacity for rapid innovation in products, services, processes, and strategies, and this distinguishes them from traditional high volume mass production or service companies of previous decades. Polytechnic's new executive program in technology management is designed for a wide range of managers who need to acquire the knowledge and skills with which to compete in world markets that are increasingly technological, rapidly evolving and constantly changing. The primary goal of the program is to train managers in the new requirements of innovative organizations.

The program is well suited for engineers and scientists with increasing managerial responsibility in areas such as research, development, operations, computer science, and engineering. Most have already achieved some managerial responsibility, and have reached a point in their careers at which formal training in management has become important for future advancement.

The program, however, is not only aimed at practicing scientists and engineers. Professionals working in finance, banking, telecommunications, and other technological environments will also find the program of relevance and value. Business managers in functional areas such as marketing, sales, and finance who want to obtain a deeper understanding of how their technology-intensive companies work, in preparation for general management positions, would also find the Polytechnic program profitable.

The program is given in an *executive format*, that is, classes meet every other week for two full days, Friday and Saturday at Polytechnic's Westchester Center at Hawthorne, New York. Breakfast, lunch, and coffee breaks are provided. All classes are videotaped and the tapes are available for viewing on campus or at home.

An all-inclusive fee for this program covers tuition and fees, textbooks and other educational materials, special tutorials and lectures, meals on class days, and videotapes of all classes and lectures.

## ADMISSION REQUIREMENTS AND APPLICATION INFORMATION

Admission to the program requires a baccalaureate degree from an accredited institution with a superior undergraduate record, a minimum of two years work experience in the field of management and company support.

Applications for admission are accepted throughout the year, but admission is for fall semesters only, as the program is completely specified for all students. Because enrollment is limited, early application is strongly recommended.

## DEGREE REQUIREMENTS AND CURRICULUM

The general requirements for Master of Science degrees stated elsewhere in this catalog apply to this program. The curriculum consists of 12 courses (36 units) which are taken by every student. There are no elective courses or units in this program.

The 12 courses which constitute the program curriculum are:

### First Semester

- MG 603 *Organizational Behavior and Management Process in Innovative Corporations*
- MG 609 *Managerial Accounting and Finance*
- MG 865 *Managing the Innovative Process*

### Second Semester

- MG 610 *Quantitative Analysis for Managerial Decisions*
- MG 736 *Information Systems and Technology in Management*
- MG 867 *Technology Strategy*

### Third Semester

- MG 869 *Manufacturing: Productivity, Technology and Management*
- MG 607 *Marketing*
- MG 608 *Managerial Economics and the Economic Environment*

### Fourth Semester

- MG 820 *Project Assessment and Management*
- MG 870 *Managerial Implications of Current Developments in Science and Technology*
- MG 970 *Strategic Management*

## COURSE DESCRIPTIONS

The following courses are unique to this program. For other course descriptions, refer to the "Management" section of this catalog.

### MG 603 Organizational Behavior and Management Process in Innovative Corporations

Introduction to issues and concepts in organizational and administrative behavior, with emphasis on continually changing organizations. Management processes for flexible and innovative organizations. The evolution of technology-intensive industries and business organizations. The role of technology in the growth of the modern firm. Human resource management and organization development in technology-intensive firms.

## MANAGEMENT OF TECHNOLOGY

### **MG 609 Managerial Accounting and Finance**

Elements of accounting and finance of importance to managers of technology. Analysis of principles and practices of the finance function. Financing methods for internal and external ventures and innovations; capital budgeting; R&D portfolio analysis. Contrast of strategic perspectives emphasizing innovation and development with those emphasizing short-term return and investment.

### **MG 610 Quantitative Analysis for Managerial Decisions**

Application to the management of technology of quantitative and analytical techniques such as probability, statistical inference, correlation and regression, decision theory, forecasting, linear programming, and queuing models. Production/operations management techniques. Cases and problems selected from real world technology management experience including computer supported decision-making and simulation.

### **MG 736 Information Systems and Technology in Management 2 1/2:0:0:3**

Defining information needs for the management of the continually-innovating firm. Management Information Systems for operations, control and planning. Decision support systems, expert systems and AI. MIS requirements for production and office automation. Issues of hardware and software systems development, evaluation and acquisition. Problems of learning, training, privacy and security.

### **MG 869 Manufacturing: Productivity, Technology and Management**

Manufacturing technology and organizational structure. Product development and process change. Managing the learning curve: conflicts between innovation

and productivity. Manufacturing as an element of corporate strategy. Flexible manufacturing systems. Automation and information systems. CAD/CAM and computer integrated manufacturing systems. Quality control.

### **MG 870 Managerial Implications of Current Developments in Science and Technology**

A survey of specific technologies of current and emerging importance to managers. Assessments of the state of the art by experts. Emphasis on analysis of opportunities for commercial applications and threats to existing products and processes. Development of ways of thinking systematically about applications of new technologies and their implications for new products and industries.

## FACULTY

**A. George Schillinger**, Professor of Management; Director, Management of Technology Program  
B.E.E., City College of New York;  
M.S., Eng.Sc.D., Columbia University

**Ralph E. Weindling**, Head, Management Department Industry Professor of Management  
B.S., University of Pennsylvania;  
M.B.A., Harvard University

**Byron David**, Assistant Professor of Management; Program Director, Operations Management  
B.A., Queens College of CUNY;  
M.S., Polytechnic Institute of New York; M.B.A., Ph.D., Baruch College

## ADJUNCT FACULTY

**Bernard Abramson**, Adjunct Professor of Management  
B.S., Cambridge University;  
M.S., London University

**Lawrence D. Burkinsbaw**, Adjunct Professor of Management  
M.S., Fordham University; M.B.A., University of Massachusetts

**Seymour Kaplan**, Adjunct Professor of Operations Research and Management Science  
B.S., Newark College of Engineering;  
M.S., Ph.D., New York University

**E.Hart Rasmussen**, Adjunct Professor of Management; Director, Management Programs, Westchester Graduate Center  
B.S., M.S., Polytechnic University of Denmark

**Lowell W. Steele**, Adjunct Professor of Management of Technology  
B.A., Dartmouth; M.B.A., Harvard University; Ph.D., Massachusetts Institute of Technology

**Joseph Schlosser**, Adjunct Professor of Management  
B.A., Notre Dame; M.Ed., University of Massachusetts; Ph.D., Wharton School

**Duncan D. Sutphen**, Adjunct Professor of Management  
B.A., Princeton University

**Anthony J. Wiener**, Adjunct Professor of Management  
A.B., J.D., Harvard University

# MANUFACTURING ENGINEERING

Polytechnic has a strong commitment to manufacturing engineering including an M.S. program and diverse programs leading to under graduate concentrations in manufacturing.

In recent years, much has been written and said about the growing inability to compete of U.S. industry. As markets have become more global, and manufacturing operations have moved off-shore, many manufacturing jobs have been lost in the United States and the trade deficit grown large. In response, many new approaches for improving competitiveness have been introduced. Certainly, the most important of these are methods that improve competitiveness by improving quality and reducing inventory and cycle time. Hence we emphasize methods such as TQM, JIT/TQC, "pull", and Activity Based Costing. We also emphasize design for manufacturability, robust design and the design of experiments techniques such as those practiced by Professor G.E.P. Box. In production we teach CIM and modern methods of production control such as Goldratt's Synchronous Manufacturing. Success in the application of these new methods depends upon getting acceptance for their use so we address specifically the Product Realization Process, how to introduce new methods and high performance teams.

Polytechnic's comprehensive program in manufacturing engineering focuses this array of new methods together with new technologies to address directly the needs of industry. It draws upon Polytechnic's long term, well-established strengths in Engineering, Science, and Management. The program is interdisciplinary and is designed for working professionals who have responsibilities in manufacturing and for those who plan to enter manufacturing after completing the Masters Program.

Because hands-on experience is so important we have made arrangements with local manufacturers for our full-time students and those of our part-time students that do not work full time to do

a six months internship in nearby manufacturing Industry. The M.S. program, including the six months internship, can be completed in one year.

## THE M.S. IN MANUFACTURING ENGINEERING

The M.S. in Manufacturing Engineering can be taken full-time or part-time on either the Brooklyn or Westchester Campuses.

Ph.D. level work in manufacturing can be pursued in the mechanical engineering programs.

Students are drawn from a wide variety of manufacturing firms, large and small. Representative firms include ARKO, Standard Motor Products, IBM, Loral, Medical Labs Automation, Guild Moulders, Photocircuits Corporation, and AT&T Bell Labs.

The approach embodied in this program is intended to:

- Empower the engineer to build from bottom up.
- Provide experience in design and production in the internship and in projects.
- Provide hands-on experience in the use of software for design and simulation.

Students graduating from this program will be equipped with working knowledge of advanced methods and techniques in manufacturing that are in use throughout the world. They will have sufficient knowledge and hands-on experience to enable them to contribute significantly to productivity improvement and to provide leadership that such programs require. They will be well positioned to advance their own careers.

## UNDERGRADUATE CONCENTRATION IN MANUFACTURING

All undergraduate engineering programs at Polytechnic are accredited by ABET. The programs in mechanical engineering and electrical engineering explicitly allow students to use their electives to form concentrations in manufacturing.

## DESIRABLE BACKGROUNDS FOR GRADUATE STUDENTS

Admission to this graduate program is open to those holding an accredited engineering degree (BS or BE), and to graduates in Physics, Chemistry, Materials Science, and the Biological Sciences.

International students with equivalent backgrounds are eligible to participate in the program.

## REQUIREMENTS FOR THE M.S. (MANUFACTURING ENGINEERING) DEGREE

The degree program requires 36 CR, typically made up of eleven courses and a 3 CR. master's report or 10 courses and 6 CR. master's report. Credit may be granted for up to three relevant graduate level courses (9 CR.) completed elsewhere with a grade of B or better.

# MANUFACTURING ENGINEERING

## Prerequisite Knowledge (Courses or equivalent knowledge):

Probability and Statistics  
(MA562 or equivalent)

Engineering Economy  
(IE 600 or equivalent)

Computer Literacy  
(ME 101 or equivalent)

Up to six credits of graduate courses in this category of prerequisite knowledge can be counted for degree credit as electives, although the electives needed for the student's concentration must also be satisfied.

## Required:

### Core Courses **15 Units**

- MN 788 *Manufacturing Systems Engineering*
- MN 785 *Computer Integrated Manufacturing Systems*
- MN 792 *Design for Manufacturability (DFM)*
- MN 618 *Introducing New Methods of Work—Leading Change*
- MN 611 *Quality Control and Improvement*

### Other Courses **21 units**

Students are encouraged to organize their electives into "concentrations". Concentrations are designed to suit the student's career needs and, for those who are working, the needs of the firm. Concentrations are designed by the student together with a faculty adviser and/or his employer. Any course in the Polytechnic catalog that is so approved may be elected as part of a concentration.

## Illustrative Concentrations:

### Product Realization Concentration

- MN 911 *The Product Realization Process*
- MN 912 *High Performance Teams*
- MN 612 *Quality Engineering Using Robust Design*
- IE 619 *Production Planning and Control*
- MN 794 *Physical Design*

Note: MN 911- and MN 912 are listed in the course descriptions as Selected Topics in Manufacturing Engineering I-11.

### Production Concentration

- MN 911 *The Product Realization Process*
- MN 612 *Quality Engineering Using Robust Design*
- IE 682 *Factory Simulation*
- MN 776 *Manufacturing Resources Planning (MRP)*

## Electronics Devices Concentration

- MN 612 *Quality Engineering Using Robust Design*
- MN 802 *Thermal Design of Electronics Systems for Performance and Reliability*
- MN 804 *Thermal Issues in Manufacturing Processes*
- MT 707 *Thin Film Technology*
- MT 709 *Integrated Circuits (VLSI) Fabrication Techniques*

## LABORATORY AND PROJECT WORK

Students may use the laboratory facilities at Polytechnic in their master's report work or in special courses focused on such tools. Consult the academic adviser to arrange for a special offering if needed.

## MASTER'S REPORT

The M.S. Report may be expanded to 6 units by use of MN 997 as an elective. The M.S. Report is done in an industrial lab setting whenever possible. Local industries with plants accessible to both campuses offer internships in many types of manufacturing.

Part-time students may draw upon their work to provide appropriate master's reports or theses. Full time students may also work on theoretical or experimental research projects at Polytechnic. In all cases, a faculty adviser is assigned. Oral presentations of the project/thesis proposal are required at the start of the work. A written report and an oral presentation are required upon completion of the project.



The laboratories used the Manufacturing Engineering Program include a network of PS/2 Model 70's, and a network of RT workstations using CAEDS; this equipment was provided as part of the IBM CIM Alliance. The physical laboratories include scale CNC machines, two industrial robots, a controls and robotics laboratory, and research facilities in flexible structures and in thermal sciences.

The laboratory and project activities associated with Manufacturing include:

Simulation Laboratory, using such tools as Promodel, Simfactory, Xcell+, and other tools Design for Manufacturability Project, using DFM software to study and evaluate designs, such as vehicle subsystems (a recent project with the Ford Motor Company);

Process and Work Flow Methods, including applications of LabView; for efficient real time data collection and closed loop control

## GRADUATE COURSES

The courses with MN designations, are shown below, followed by a set of courses from other programs which are commonly taken by Manufacturing Engineering students.

### MN 611 Quality Control and Improvement *2/::0:0:3*

Review of the concepts of the cost of quality, quality assurance, quality process control, and total quality management. Emphasis on process and product design changes to improve quality and on process management and control. Control charts and their use: the concept of "out of control"; charts based upon variables and charts based on attributes. Specifications and tolerances. Acceptance sampling by lots, including concepts of producer's and consumer's risks. A course project is required. *Prerequisite: MA 561 Also listed as IE 611.*

### MN 612 Quality Engineering Using Robust Design *2/::0:0:3*

The fundamental principles of robust design and quality loss practiced by G. Taguchi are developed. Design of experiment techniques using orthogonal arrays are discussed in detail as well as other methods for product/process improvement. Applications of these procedures are reviewed including on-line troubleshooting methods to assure quality in manufacturing. *Prerequisite: IE 611. Also listed as IE 612.*

**MN 618 Introducing New Methods:  
Leading Change** 2½:0:0:3

New methods of work embodied in new production paradigms such as JIT/TQC and "pull", computer-mediated work, the end-to-end Product Realization Process and the changed demands on established ways of working for both workers and managers are the focus of this course. The impact of corporate culture and the associated human issues are described.

**MN 776 Manufacturing Resources  
Planning** 2½:0:0:3

Quantitative models for analysis of production and inventory management systems. Topics covered include bill of materials structures, time-phased parts requirements, shop loading and capacity, constraints, priority planning and control, and schedule regeneration. Development of computer-based MRP systems. **Also listed as IE 776.**

**MN 785 Computer Integrated  
Manufacturing Systems (CIMS)**  
2½:0:0:3

The basic concepts of manufacturing complex products with complex processes relying heavily on computer and data processing technologies are introduced. All aspects relative to products and processes - planning, design, manufacturing, shipping - are addressed from a variety of perspectives. Techniques for managing and optimizing manufacturing productivity are explored. **Also listed as IE 785.**

**MN 788 Manufacturing Systems  
Engineering** 2½:0:0:3

Topics concentrate on contemporary techniques for product design and manufacture including financials of the manufacturing firm, quality, reliability, Taguchi methods of product and process design, scale-up and partitioning, production flows, modern manufacturing methods such as JIT/TQC, pull and synchronized manufacturing. Cultural factors are also discussed **Also listed as IE 788.**

**MN 792 Design for  
Manufacturability (DFM)** 2½:0:0:3  
Concepts and techniques for the eco-

nomie, functionally sound and high quality product design for manufacture are introduced. Emphasis is placed on designing for easy assembly, both robotic and manual, and to the effective use of plastics for manufacturing cost reduction. Managerial and organizational approaches and case studies of successful designs are reviewed. **Also listed as IE 792.**

**MN 794 Physical Design of  
Products** 2½:0:0:3

Physical Design prepares students to make component and assembly characteristic decisions using the traditional analytical tools such as kinematic, kinetic, static and cyclic stress/strain analyses. Specific components such as cams, gears and threaded details are used for examples. Case studies of actual design activities are presented. The students do a group design project in their field of interest utilizing several of the elements of design and analysis

**MN 798 Electronic Data Interchange  
(EDI)** 2½:0:0:3

The impact of EDI on business functions and the accompanying management and technical issues are reviewed. Also reviewed are standards, structures and technical aspects for networking and communications and measures of EDI costs and benefits. Case studies of key EDI application areas are given.

**MN 802 Thermal Design of  
Electronics Systems for Performance  
and Reliability** 2½:0:0:3

Thermal modeling and simulation of electronic equipment and systems, forced and natural air cooling, cooling with water and other liquids, cryogenic cooling, use of cooling correlations, approximate numerical formulations, fan characteristics, fan and disc acoustic noise, chip thermal profiles, thermal influence on the reliability of semiconductor circuits. **Also listed as ME 717.**

**MN 804 Thermal Issues in  
Manufacturing Processes** 2½:0:0:3

Thermal modeling and simulation of manufacturing and materials processing, thermally driven processes, dip coating,

thin films, soldering, laser welding and cutting, heat removal from processes generating parasitic heat, thermal management of machining. **Also listed as ME 718.**

**MN 911-912 Selected Topics in  
Manufacturing Engineering I-II**  
3 units

Areas not covered in other courses. Specific topics vary according to the instructor, who may be a visiting professor. Topics and prerequisites will be announced during the term prior to the offering.

**MN 930-931 Readings in  
Manufacturing Engineering I-II**  
3 units

Individual reading of selected papers and current literature in specialized area of study, guided by faculty member. The topic must be beyond the scope of regularly offered courses. The topic must be agreed upon by the student and adviser prior to registration. A written report on the topic is required. *Prerequisite: approval of adviser, instructor, and department head.*

**MN 996 M.S. Report I** 3 units

Independent project demonstrating professional maturity and graduate-level knowledge completed under guidance of departmental adviser. Experimental work, software development, extensive analysis are commonly expected. Report must include results in one or more of these areas and a critical analysis and interpretation of pertinent literature and should represent worthwhile contribution to the field. Written report (unbound) is required.

**MN 997 M.S. Report II** 3 units

With the approval of the graduate adviser, some students may undertake a six credit MS report. This should be planned in advance, during the registration for MN996. In such cases, MN997 is used for the second half of the registration. A grade of "S" or "U" is awarded in MN996 in these cases, and the letter grade given in MN997 applies to all six units. *Prerequisite: Adviser's approval.*

## MANUFACTURING ENGINEERING

### IE 619 Production Planning and Control 2 1/2:0:0:3

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.

### IE 620 Project Planning and Control 2 1/2:0:0:3

Network-planning techniques for project management and resource allocation. Emphasis on PERT, CPM and other probabilistic generalized networks. Heuristic models for multi-project scheduling and resource leveling. Other topics include network development, computer adaptation, project reports and project monitoring. *Prerequisite: knowledge of computer programming.*

### IE 621 Facility Planning and Design 2 1/2:0:0:3

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 layout design. Other topics include computerized layout planning, materials handling systems, evaluation and improvement of facility productivity.

### IE 682 Systems Simulation with Factory and other Applications 2 1/2:1:0:3

Modeling and simulation of complex industrial, commercial and service systems, such as factories and hospitals. Students develop, run, and experiment with several simulation models using different software packages. *Prerequisite: knowledge of computer programming.*

## OTHER GRADUATE COURSES RELATED TO MANUFACTURING

The manufacturing engineering orientation of several engineering programs is described in this section.

### MECHANICAL ENGINEERING

Mechanical 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 have a strong background in manufacturing through such courses as:

- Finite Element Analysis
- Thermal Design
- Synthesis of Mechanical Systems
- Analysis/Design of Machine Elements
- Computer Graphics in CAD

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:

- Fundamentals of Biochemical Engineering
- Chemical Processes
- Kinematics I and II
- Polymer Processing
- Environmental Engineering

### 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 semiconductor technology are also cross-listed with electrical engineering.

### 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 Design and Engineering
- Data-base Management Systems
- Microprocessors
- Data Communications Networks
- Computer Graphics and Image Processing
- Interactive Computer Graphics
- Artificial Intelligence
- Pattern Recognition

These encompass both graduate and undergraduate offerings.

**FACULTY**

All of the faculty for the Polytechnic M.S. Program in Manufacturing Engineering have extensive, current experience in industry. Each faculty member brings to the program some unique background and experience applicable to the course of study. For example, Prof. Hoover was formerly Executive Director of Interconnection Technology and Power Systems at AT&T-Bell Labs. Professor Levine was at AT&T-Bell Labs where he was Director of the Transmission Systems Engineering and was also Director of the Bell Labs Education Center. He has extensive experience in effecting cultural change and guiding organizational transition.

**Charles W. Hoover, Jr.**, Industry Professor and Director of the Manufacturing Engineering Program. B.E., Yale University; B.S., MIT; M.S. and Ph.D., Yale  
*Manufacturing systems engineering and physical design.*

**Nathan Levine**, Professor of Manufacturing and Industrial Engineering. B.S., M.I.T.; M.S., U. of Illinois; Ph.D., U. of Illinois  
*Quality control and improvement, quality engineering using robust design.*

**Charles A. Kelly**, Professor of Manufacturing and Industrial Engineering. B.S., Syracuse University; M.S., University of Detroit  
*Work methods, design of manufacturing systems, computer aided engineering*

**George C. Vradis**, Assistant Professor of Mechanical Engineering. Dipl. ME National Technical University (Greece); M.S., Ph.D. Polytechnic University.  
*Fluid/thermal studies, unsteady flows, energy transfer.*

**Sunil Kumar**, Assistant Professor of Mechanical Engineering B. Tech., Indian Institute of Technology; M.A., M.S., State University of New York. Ph.D., University of California at Berkeley. *Thermal management of manufacturing systems.*

**M. Karim Moallemi**, Assistant Professor of Mechanical Engineering B.S.M.E., Pahlavi University (Iran); M.S.M.E., Ph.D., Purdue University. *Thermal analysis and design, thermal testing and evaluation and thermal aspects of materials processing and manufacturing systems.*

**Anthony Tzes**, Assistant Professor of Mechanical Engineering. B.S.M.E., University of Patras (Greece); M.S., Ph.D., Ohio State.  
*Robotics, automation and expert control.*

**Terance Kinsky**, Instructor of Mechanical Engineering. B.S.M.E., University of Maryland  
*Engineering graphics, computer aided engineering, manufacturing applications.*

**ADJUNCT FACULTY**

**James G. Bralla**, Adjunct Professor. P.E.; B.S.M.E., Princeton University; M.S., Polytechnic University  
*Design for manufacturability and manufacturing processes.*

**Richard Bellingham**, Adjunct Professor. B.A. Western Michigan; M.A. Western Michigan; Ed.D. Western Michigan.  
*Development of high performance teams.*

**David Friedman**, Adjunct Professor B.S., Johns Hopkins; M.S., Ph.D., Georgia Tech.

**Daniel T. Koenig**, Adjunct Professor. B.S. U.S. Coast Guard Academy; M.S. Union College.  
*Computer integrated systems.*

**Cal Oltrogge**, Adjunct Professor. B.A., University of California at Los Angeles; M.A., Stanford; Ph.D., New York University.  
*Change management, work design, personnel research, retraining and resource balancing.*

**Subramani Rajaram**, Adjunct Professor. B.E., Bangalore University (India); M.A.Sc., University of Waterloo (Canada); Ph.D., State University of New York at Buffalo.  
*Heat transfer and thermal design.*

**Duncan D. Sutphen**, Adjunct Professor B.A., Princeton. Formerly Vice President, Operations, Dresser Pump Division of Worthington Corporation.  
*Manufacturing operations and manufacturing strategies.*

**John Thomas**, Adjunct Associate Professor. B.A., University of Michigan; M.B.A., University of Rochester.  
*Production control and manufacturing resources planning.*

**John Zuk**, Adjunct Lecturer. B.S., Union College; M.S., Polytechnic University.  
*Modeling of manufacturing systems, computer simulation and robotics.*

**Michael Greenstein**, Adjunct Assistant Professor. B.S., CCNY; M.B.A., U. of Louisville.  
*Design for manufacturability.*

**Steven Bernstein**, Adjunct Assistant Professor. M.S., U. of Michigan; B.S., Fairleigh Dickinson.  
*Physical design.*

**Reuven Shapira**, Adjunct Associate Professor. B.S., Technion Institute of Technology; M.S., University of TelAviv, Israel.  
*Production Planning and Control, ISO9000, Quality Driven Process Management*

# MATERIALS SCIENCE AND ENGINEERING

Materials scientists are specialists in the most effective utilization of metals, alloys, ceramics, semiconductors, composites, plastics and polymers. Their expertise is vital to the solution of problems arising from the intensive quest for superior materials in our rapidly advancing technological age.

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.

## MATERIALS SCIENCE

It is estimated that nearly 40% of all engineering RESEARCH is in the area of materials science, which is defined as the study of the interrelation among atomic structure, crystal structure, microstructure and properties of materials. The fundamental principles, which involve basic physics and chemistry, are universally applied to metals, ceramics, polymers, semiconductors, nano materials, intermetallic compounds and composites. With this understanding it is possible to "tailor make" materials requiring specific properties for particular applications.

## MATERIALS ENGINEERING

Traditionally, the study of structure-property relationships was the specialty of the physical metallurgist. As a result of this history there exists a strong emphasis in metals in the materials science curriculum and a student may elect to pursue a major in this discipline.

Engineering applications of metallic materials directly reflect on the electron-

ic, 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 processes for 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 do consulting. Metallurgists are instrumental in contributing to progress in medical prosthetics, dental materials, environmental protection, electronic devices and materials, superconducting materials, thermoelectric materials and advanced aerospace materials to name some important areas.

## DEGREES OFFERED

The Department of Materials Science and Engineering prepares students for the degrees of Master of Science in materials science or materials engineering, and the degree of Doctor of Philosophy in materials science. The M.S. and Ph.D. degrees are offered at the Brooklyn Campus and the M.S. degrees are offered at the Westchester Campus.

Both fundamental and applied research are carried out within the Department. Excellent facilities are available for work in electron microscopy, surface analysis, deformation and fracture and other fields. Fundamental research is carried out on alloy hardening, deformation and fracture, phase transformations, thermomechanical working, microstructures and

properties, failure analysis, intermetallic compounds and composites, surface analysis, ferroelectric thin films and rapid solidification. In applied research, the Department is involved in studies of materials for aerospace, electronics, and energy related applications.

## DEGREE(S) REQUIREMENTS

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. Materials Engineering Required Course Work:

Take 9 units from:

MT 600	<i>Structure-Property Relationships</i>	3
MT 610	<i>Thermodynamics of Metals and Alloys</i>	3
MT 620	<i>Plastic Deformation &amp; Fracture</i>	3
MT 630	<i>Theory of Metals</i>	3
MT 640	<i>Reactions in Solids</i>	3
MT 650	<i>Advanced Engineering Metallurgy</i>	3

### Project or Thesis\*

MT 996	<i>Project for M.S.</i>	3-6
	or	
MT 997	<i>Thesis for M.S.</i>	9-12

### Elective Course Work:

9-24 units chosen from the Department courses listed in the Catalog.	9-24
--	------

**Engineering or Science Electives:**

With adviser's approval may be chosen from among University courses offered: 0-6  
 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.

CM 515 *Polymer Organic Chemistry*  
 MT 540 *Survey of Metallurgical Principles*

(These courses may not carry credit towards degrees)

MT 600 *Structure Property Relationships* 3  
 MT 640 *Reactions in Solids* 3  
 MT 660 *Ceramic Technology* 3  
 CM 771 *Introductory Polymeric Chemistry* 3

**Project or Thesis\***

MT 996 *Report Project for M.S.* 3-6  
 or  
 MT 997 *Thesis for M.S.* 9-12

**Elective Course Work:**

With adviser's approval courses may be chosen from the Catalog and others in areas related to materials science, e.g., physics, chemistry and polymers. 12-21  
 Total 36

\*Part-time students take Project.

**REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY**

Requirements for doctor's degree conform to regulations in Degree Requirements. Special doctoral requirements are available from the Departmental Administrative Assistant in the publication, Guide for Doctoral Students in Metallurgy or Materials Science.

A typical program consists of a minimum of 24 units of research for the doctoral dissertation and sufficient units of graduate course work for a total of 90 units required by Polytechnic. A minimum of 48 units of graduate course work beyond the bachelor's degree is normally required by the Department.

Courses include major concentration in materials science of 36 units and minor concentrations of 12 units in related areas of physics, chemistry, mathematics, mechanical engineering, etc.

Students are also required to pass a series of oral qualifying examinations, traditionally taken within the first two years of study and, in addition, after the thesis is completed, it must be defended.

**INTERDEPARTMENTAL COURSES**

**MT 305 Mechanical Properties of Materials** 3:0:3

Structure-property relationships of engineering materials. Testing methods and interpretation of tests, mechanical properties of materials. Engineering properties of ferrous and non-ferrous alloys and non-metallic materials including polymers, ceramics and composites. Strong emphasis is placed on engineering applications and case histories of product and component failures.

**MT 306 Nature and Properties of Structural Materials** 2:3:3

Physical and mechanical properties of concrete, metals, plastics, composites and asphaltic materials related to structures. Experimental investigation of mechanical properties of selected structural materials and physical properties of cement and concrete mixes. Introduction to polymeric materials including geosynthetics. Jointly developed and taught by Civil & Environmental Engineering and the Metallurgy & Materials Science Departments. Also listed under CE 306.

**MT 340 Manufacturing Processes** 3:0:3

Mechanical behavior of metals. Properties of materials relating to fabrication methods. Metal cutting mechanics, cutting fluids, thermal and vibrational aspects of machining. Machinability criteria. Deformation processing, hot and cold, mechanics of deformation. Unconventional processing: EDM and ECM. Numerical control. Metrology. Prerequisite: MT 305. Also listed under IE 340.

**MT 375 Semiconductor Technology** 3:0:3

Principal techniques involved in design and fabrication of semiconductor devices and integrated circuits, including material preparation, junction forming, circuit integration, packing. 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. Manufacture and processing of polymers. Mechanical behavior of polymers and their thermal and electrical properties. Prerequisites: CM 161, CM 162, CM 123 and CM 124. Also listed under CH 371.

**GRADUATE COURSES**

**MT 540 Survey of Metallurgical Principles** 2 1/2:0:3

Crystals structures, alloying, phase diagrams, diffusion phenomena, mechanical deformation of metals and alloys, recrystallization, age hardening. Prerequisite: instructor's consent.

**MT 600 Structure-Property Relationships in Materials** 2 1/2:0:3

Dependence of properties, e.g., mechanical and electrical, on structure of materials. Crystalline vs. amorphous structure, occurrence and role of defects. Bonding and structure. Anisotropy of properties related to crystal symmetry. Polycrystal vs. single crystal vs. textured polycrystals. Prerequisite: MT 410 or equivalent.

## MATERIALS SCIENCE AND ENGINEERING

### MT 601-602 Special Topics in Structure-Property Relationships, I, II 2½:0:3

Advanced or specialized topics in structure-property relationships in materials presented at irregular intervals. *Prerequisite: MT 600.*

### MT 603 Introduction to Electron Microscopy I 2½:0:3

Resolving power. Lens aberrations. Properties of magnetic lenses. Designs of Transmission and Scanning Electron Microscopes, their applications and limitations. Real and Reciprocal lattices. Scattering of fast electrons by atoms. Theories of electron diffraction. Bragg Law. Ewald sphere construction.

### MT 604 Introduction to Electron Microscopy II 2:2:3

Image formations. Fresnel half period zones. Kinematical theory of image formation. Column approximation. Images of perfect and imperfect crystals, stacking faults, dislocations, precipitates. Amplitude phase diagram and its applications. Breakdown of Kinematical theory. Introduction to dynamical theory of image formation. Specimen preparation techniques: thin foil, replicas. Uses of the Scanning and Transmission Electron Microscopes.

### MT 610 Thermodynamics of Metals and Alloys 2½:0:3

Fundamentals of classical and statistical thermodynamics with emphases on solid states, phenomenology of metallic surfaces, phase equilibria in multicomponent metallic systems, calculations of phase diagrams, thermodynamics of lattice defects and substructure. *Prerequisite: MT 405.*

### MT 611-612 Special Topics in Thermodynamics and Statistical Mechanics of Metals, I, II each 2½:0:3

Advanced or specialized topics in thermodynamics and statistical mechanics of metals. *Prerequisite: MT 610.*

### MT 620 Plastic Deformation and Fracture 2½:0:3

Classical concepts of slip related to dislocation theories of stress-strain behavior of single crystals. Mechanical twinning and its relationship to crystal structure. Theories of yielding, brittle and ductile fracture in polycrystalline materials. *Prerequisite: MT 406.*

### MT 621-622 Special Topics in Deformation and Fracture I, II 2½:0:3

Advanced or specialized topics in deformation and fracture. *Prerequisite: MT 620.*

### MT 630 Theory of Metals 2½:0:3

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

Advanced or specialized topics in electronic properties of materials. *Prerequisite: MT 630*

### MT 640 Reaction in Solids each 2½:0:3

Mechanism and kinetics of diffusion-controlled and diffusionless phase transformations in solid metallic systems; diffusion in multiphase, multicomponent metallic systems; theories of precipitation, of grain boundary migration and grain growth, of eutectoid transformation and martensitic transformations. *Prerequisite: MT 414.*

### MT 641-642 Special Topics in Reactions in Solids I, II each 1½:0:3

Advanced or specialized topics in reactions in solids. *Prerequisite: MT 640 or instructor's consent.*

### MT 650 Advanced Engineering Metallurgy 2½:0:3

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 2½:0:3

Advanced or specialized topics in advanced engineering metallurgy presented at regular intervals. *Prerequisite: MT 405.*

### MT 660 Ceramic Technology 2½:0:3

Chemistry, structure and properties of ceramics and glasses. Emphasis on relation of microstructure 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 706 Magnetism and Magnetic Materials 2½:0:3

Origin of magnetism in atoms and solids. Diamagnetic vs. paramagnetic behavior. Ferromagnetic domain theory. Antiferromagnetism and ferromagnetism. Structure and properties of magnetic materials. *Prerequisite: MT 410.*

### MT 707 Thin Film Technology 2½:0:3

Preparation, structure, evaluation and properties of thin films: metallic, semiconductor and dielectric film techniques, nucleation and growth considerations, epitaxy, and metastable configurations. *Prerequisite: instructor's consent.*

### MT 708 Semiconductor Materials and Devices 3:0:3

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.

**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, interconnection and packaging to final test are analyzed. The impact of process on design rules are printed out. Also listed under EL 646.

**MT 714 Electrochemical Processes** 2½:0:3

A presentation of the fundamentals of electro-chemical reactions, focussing on those aspects which have application to metals and semiconductors. Electrode reactions; kinetics of electrode processes, theory and applications of chemical etching; corrosion of metals and alloys; electro-solution and deposition.

**MT 720 Advanced in Materials Analyses Mechanisms in Metals** each 2½:0:3

Characterization 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 760-761 Seminar in Metallurgical Engineering** each 0:2½:1½

Recent progress in metallurgical engineering addressed 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 and to be conversant with

topics presented. (Attendance required for two semesters. Part-time students may substitute a three unit metallurgy course).

**MT 762 Seminar in Metallurgical Engineering** 0:2½:0

Preparation of 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 763-764 Seminar in Metallurgy and Materials Science** each 0:2:½

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 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 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** 9-12 units

An original topic of research for the master's degree is decided upon by student and faculty adviser. Close contact is to be maintained between student and faculty adviser during the thesis investigation. After the thesis is written up and approved the student is required to defend his thesis during an oral examination.

**MT 998 Project for the Engineer Degree** 3-6 units

Engineering project at post-master's level pursued with 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 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 examinations on thesis subject and related topics. Minimum of 35 units required.

The following graduate courses are offered irregularly in response to student demand:

- MT 700 Welding Metallurgy
- MT 710 Powder Metallurgy II
- MT 715 Corrosion & Oxidation Mechanism in Metals
- MT 725 Noble Metal Metallurgy
- MT 726 Metallurgy of Nuclear Reactor Materials
- MT 727 Bioengineering Metallurgy
- MT 740 Materials in Manufacturing

**FACULTY**

**Said Nourbakhsh**, Professor of Metallurgy and Acting Head of Materials Science & Engineering. B.S., Arya-Mehr University of Technology (Iran); Ph.D., Leeds University (England).

*Phase transformation, electron microscopy, mechanical behavior, composite materials, smart materials and ferroelectric thin films.*

**Carmine D'Antonio**, Professor of Metallurgy. B.Met.E., M.Met.E., Polytechnic Institute of Brooklyn. *Mechanical properties, thin films, failure analysis.*

**Sung H. Whang**, Professor of Metallurgy. B.S., Seoul National University (Korea); M.S., D.Eng.Sc., Columbia University.

*Alloy phase stability, rapid solidification processing, superconducting materials processing, deformation in ordered intermetallic materials.*

## MATERIALS SCIENCE AND ENGINEERING

**Sharmila M. Nukhopadhyay**, Assistant Professor.

M.S. (Physics), Indian Institute of Technology (India), M.S. (Materials Science & Engineering); Ph.D., Cornell University.

*Ceramics, properties of surfaces and interfaces and electron spectroscopy.*

**Harola Margolin**, Distinguished Professor of Research, B.Eng., M.Eng. and D.Eng.Sc., Yale University.

*Plastic deformation and fracture, titanium metallurgy, fatigue of metals and alloys.*

### ADJUNCT FACULTY

**Sung R. Kang**, Adjunct Professor of Metallurgy.

B.S., Met.E., Seoul National University (Korea); Ph.D. (Met.E.), University of Pennsylvania.

**Ernest Levine**, Adjunct Professor of Metallurgy.

B.Met.E., Rensselaer Polytechnic; Ph.D., Polytechnic Institute of New York.

**Sankar Sastri**, Adjunct Professor of Metallurgy.

B.S., Indian Institute of Science (India); M.S., Columbia University; Ph.D., Polytechnic Institute of New York.

**Sheldon Weinig**, Adjunct Professor of Materials Science.

Fellow of the Polytechnic University; B.S. (ME), New York University; Ph.D., Columbia University.

### EMERITUS FACULTY

**Irving B. Cadoff**, Professor Emeritus of Materials Science B.M.E., C.C.N.Y.; M.M.E., D.Eng.Sc., New York University.

*Electronic materials, liquid metal embrittlement, thin film epitaxy.*

**Louis S. Castleman**, Professor Emeritus of Metallurgy, S.B., Sc.D., Massachusetts Institute of Technology.  
*Diffusion in solids, biomaterials.*

**George J. Fischer**, Professor Emeritus of Metallurgy, B.Met.E., M.Met.E., Polytechnic Institute of Brooklyn.  
*Corrosion and welding metallurgy.*

### Admissions Requirements:

In order to be admitted to the master's or Ph.D. 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.

### Fellowships/Assistantships:

Financial assistance is available in the form of Teaching Assistantships, Research Assistantships and half tuition to full-time students. Awards are based on scholarship.

# 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 PROGRAMS

The undergraduate program in mathematics provides both a background for advanced study or subsequent research in abstract or applied mathematics and training for those students who expect to terminate their formal education with a 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 for 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 either of two courses of study. Students wishing to focus their studies within mathematics itself and in applying mathematics to other fields may elect the program leading to the BS in Mathematics. Students wishing to incorporate extensive physics into their mathematical training may elect the program leading to the BS in Mathematics and Physics. These two programs provide basic grounding in mathematical knowledge. Details of each follow.

## REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE IN MATHEMATICS

	Credits
<i>MA</i> 106, 107, 108, 109, 153, 154, 201, 202, 217, 223, 224, 260, 358, 385, 386	47
<i>CS</i> 200; <i>PH</i> 107, 108, 109, 118, 119; <i>CM</i> 101, 102, 111, 112	19
<i>HU</i> 101, 110, 200; <i>SS</i> 104	12
<i>Minor Specialties*</i>	18
<i>Humanities/Social Science electives</i>	15
<i>Free electives, with adviser approval</i>	17
	128

**\*Minor specialty:** at least nine credits beyond the required courses in a single area of study outside the Department of Mathematics. 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 adviser of the department of interest should be consulted. This requirement may be satisfied by either two minor specialties or one eighteen credit specialty. 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.

The following are possible minor concentrations:

- Aerospace
- Statistics
- Chemistry
- Computers
- Environmental Science
- Industrial Engineering/Operations Research
- Management
- Physics
- Psychology
- Economics
- Electrical Engineering Systems
- English Literature
- Transportation

**Advanced Placement** - Advanced placement credits may be given for the first year of calculus. Students receiving grades of 4 or 5 in Calculus BC 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.

## REQUIREMENTS FOR THE DUAL BACHELOR OF SCIENCE DEGREE IN MATHEMATICS AND PHYSICS

A joint major for the BS degree in Mathematics and Physics is offered at the Polytechnic.

The purpose of the Joint Major is to offer a student an opportunity to gain competence in two different and substantial fields of science, to such an extent that upon earning a Bachelor's degree, they are able to qualify for industrial positions in two distinct areas, or to go on to graduate studies in either of the two subjects.

	Credit
<i>MA</i> 106, 107, 108, 109, 153, 201, 202, 217, 223, 224, 260, 358, 385	41
<i>PH</i> 107, 108, 109, 118, 119, 210, 244, 302, 311, 323, 324, 335, 336, 347, 373, 374, 390	41
<i>CS</i> 200; <i>CM</i> 101, 102, 111, 112	9
<i>HU</i> 101, 110, 200; <i>SS</i> 104	12
<i>Humanities/Social Science electives</i>	15
<i>Free electives, with adviser approval</i>	10
	128

# MATHEMATICS AND STATISTICS

## TYPICAL COURSE OF STUDY FOR THE BACHELOR OF SCIENCE DEGREE IN MATHEMATICS (Starting Fall 1993)

### FRESHMAN YEAR

No.	Subject	Hours/Week			
		Cl.	Lab.	Rec.	Cr.
<b>First Semester</b>					
MA 106	Calculus I	3	0	2	4
CS 200	Intro. to Prog. Math.	3	0	1	3
CM 101	Gen. Chem. I	3	0	0	2
CM 111	Gen. Chem. Lab I	0	1 1/2	0	1/2
HU 101	Writing & the Humanities I	3	0	0	3
	Free Elective				3
SL 101	Freshman Sem.	1	0	1	0
					<u>16</u>

### Second Semester

MA 107	Calculus II	3	0	2	4
PH 107	Mechanics	3	0	1	3
CM 102	Gen. Chem. II	3	0	0	2 1/2
CM 112	Gen. Chem. Lab II	0	1 1/2	0	1/2
HU 200	Writing & the Humanities II	3	0	0	3
	Free elective	3	0	0	3
					<u>16</u>

### SOPHOMORE YEAR

#### First Semester

MA 108	Diff. Eqs. & Num. Meth.	3	0	0	3
PH 108	Elec., Magn., & Fluids	3	0	1	3
PH 118	Lab for PH 108	0	1 1/2	0	1 1/2
MA 153	Lin. Alg.	3	0	0	3
SS 104	Contemp. World Hist	3	0	0	3
	Minor Spec.				3
					<u>15 1/2</u>

#### Second Semester

MA 109	Multidimensional Calc.	3	0	1	3
HU 110	Prof. Report Writing	3	0	0	3
MA 154	Elem. Abs. Alg.	3	0	0	3
PH 109	Waves, Optics, & Thermo	3	0	1	3
PH 119	Lab for PH 109	0	1 1/2	0	1 1/2
	Minor Spec.				3
					<u>15 1/2</u>

### JUNIOR YEAR

#### First Semester

MA 201	App. Anal. I	3	0	0	3
MA 223	Intro. to Prob.	3	0	0	3
MA 358	Numerical Anal.	3	0	0	3
HS	Hum/SS Elect. <sup>2</sup>	3	0	0	3
	Minor Spec.				3
	Free Elect				3
					<u>18</u>

#### Second Semester

MA 202	App. Anal. II	3	0	0	3
MA 224	Intro. to Math. Stat.	3	0	0	3
MA 260	Vect. Anal. & PDE	3	0	0	3
HS	Hum/SS Elect. <sup>2</sup>	3	0	0	3
	Minor Spec.				3
					<u>15</u>

### SENIOR YEAR

#### First Semester

MA 217	Comp. Var.	3	0	0	3
MA 385	Guided Reading	3	0	0	3
HS	Hum/SS Elect.	3	0	0	3
	Minor Spec.				3
	Free Elect				5
					<u>17</u>

#### Second Semester

MA 386	Guided Reading	3	0	0	3
HS	Hum/SS Elect.	6	0	0	6
	Minor Spec.	3	0	0	3
	Free Elect.	3	0	0	3
					<u>15</u>

Consult the "UNIVERSITY DEGREE REQUIREMENTS" section of the catalog for variations in the mathematics and humanities sequence which may be required based upon placement examination performance.

<sup>1</sup>HU/SS electives must meet the concentration requirements described in the section of this catalog entitled "UNIVERSITY DEGREE REQUIREMENTS" subsection "Humanities and Social Science electives for Engineering and Computer Science majors"

#### Electives

Elective courses are chosen in consultation with the undergraduate adviser in the Mathematics Department.

## TYPICAL COURSE OF STUDY FOR THE DUAL BACHELOR OF SCIENCE DEGREE IN MATHEMATICS AND PHYSICS (Starting Fall 1993)

### FRESHMAN YEAR

No.	Subject	Hours/Week			
		Cl.	Lab.	Rec.	Cr.
<b>First Semester</b>					
MA 106	Calculus I	3	0	2	4
CS 200	Intro. to Prog. Math.	3	0	1	3
CM 101	Gen. Chem. I	3	0	0	2
CM 111	Gen. Chem. Lab. I	0	1 1/2	0	1/2
HU 101	Writing & the Humanities I	3	0	0	3
	Free Elective				3
SL 101	Freshman Sem.	1	0	1	0
					<u>16</u>

#### Second Semester

MA 107	Calculus II	3	0	2	4
PH 107	Mechanics	3	0	1	3
CM 102	Gen. Chem. II	3	0	0	2 1/2
CM 112	Gen. Chem. Lab. II	0	1 1/2	0	1/2
HU 200	Writing & the Humanities II	3	0	0	3
	Free elective	3	0	0	3
					<u>16</u>

### SOPHOMORE YEAR

#### First Semester

MA 108	Diff. Eqs. & Num. Meth.	3	0	0	3
PH 108	Elec., Magn., & Fluids	3	0	1	3
PH 118	Lab for PH 108	0	1 1/2	0	1 1/2
MA 153	Lin. Alg.	3	0	0	3
SS 104	Contemp. World Hist	3	0	0	3
PH 210	Anal. Mech.	3	0	0	3
					<u>15 1/2</u>

#### Second Semester

MA 109	Multidimensional Calc.	3	0	1	3
HU 110	Prof. Report Writing	3	0	0	3
MA 358	Numerical Anal.	3	0	0	3
PH 109	Waves, Optics, & Thermo	3	0	1	3
PH 119	Lab for PH 109	0	1 1/2	0	1 1/2
PH 234	Intro. Mod. Phys.	2	0	0	2
					<u>14 1/2</u>

### JUNIOR YEAR

#### First Semester

MA 201	App. Anal. I	3	0	0	3
MA 223	Intro. to Prob.	3	0	0	3
PH 311	Thermodynamics	3	0	0	3
HS	Hum/SS Elect. <sup>2</sup>	3	0	0	3
PH 323	Elec. & Magn. I	2	0	0	2
PH 335	Quantum Phys.	3	0	0	3
					<u>17</u>

#### Second Semester

MA 202	App. Anal. II	3	0	0	3
MA 224	Intro. to Math. Stat.	3	0	0	3
MA 260	Vect. Anal. & PDE	3	0	0	3
HS	Hum/SS Elect. <sup>2</sup>	3	0	0	3
PH 324	Elec. & Magn. II	2	0	0	2
PH 336	Quantum Mech.	3	0	0	3
					<u>17</u>

### SENIOR YEAR

#### First Semester

MA 217	Comp. Var.	3	0	0	3
MA 385	Guided Reading	3	0	0	3
HS	Hum/SS Elect. <sup>2</sup>	3	0	0	3
PH 373	Intro. to Theo. Phys. I	3	0	0	3
PH 347	Modern Optics	3	0	0	3
PH 302	Adv. Lab I	1	3	0	2
					<u>17</u>

#### Second Semester

PH 374	Intro to Theo. Phys. II	3	0	0	3
PH 390	Sen. Seminar	2	0	0	2
HS	Hum/SS Elect. <sup>2</sup>	6	0	0	6
	Free Elect.	4	0	0	4
					<u>15</u>

Consult the "UNIVERSITY DEGREE REQUIREMENTS" section of the catalog for variations in the mathematics and humanities sequence which may be required based upon placement examination performance.

<sup>1</sup>HU/SS electives must meet the concentration requirements described in the section of this catalog entitled "UNIVERSITY DEGREE REQUIREMENTS" subsection "Humanities and Social Science electives for Engineering and Computer Science majors"

#### Electives

Elective courses are chosen in consultation with the undergraduate adviser in the Mathematics Department.

**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. Doctor's degrees are offered in abstract mathematics and applied mathematics. 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. Six units may be devoted to a thesis.

No.	Required Subjects	Units
MA 621-622	<i>Real and Complex Analysis</i>	6
MA 705-706	<i>Linear and Modern Algebra</i>	6
	<i>Elective courses I</i>	8
	<i>Additional electives</i>	6
		36

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 the student's program 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**

Requirements for the doctor's degrees are 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 I, 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 materials, 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.

**UNDERGRADUATE COURSES**

**MA 105 PreCalculus 3:0:0:2**

Basic algebraic manipulations, such as working with fractions, factorization, and simplification. Solving polynomial and rational equations and inequalities. Qualitative study of functions' concepts and graphs. Graphs and behavior of common functions. The trigonometric functions and their graphs. Introduction to the derivative. Applications to physics. Introduction to the integral. Integrals of basic functions.

**MA 106 Calculus I 3:0:2:4**

Qualitative approach to functions and graphs. The concept of derivatives and its applications to curve sketching, optimization, and physics problems. The concept of integration and its applications to various fields in mathematics, physics, and engineering. *Prerequisite: Placement Exam.*

**MA 107 Calculus II 3:0:2:4**

Techniques of integration, numerical approximations of definite integrals and applications of the definite integral. Differential equations, solutions of first and second order linear differential equations. Approximations of functions, Taylor Series. *Prerequisite: MA 106 or equivalent.*

**MA 108 Differential Equations and Numerical Methods 3:0:0:3**

First order differential equations. Second order linear and nonlinear equations. Higher order linear equations. Series solutions of second order linear equations. Matrices. Systems of first order differential equations. Numerical algorithms. Numerical solution of ordinary differential equations. Linear algebraic systems. Numerical Computation of eigenvalues. *Prerequisite: MA 107 or equivalent.*

## MATHEMATICS AND STATISTICS

### MA 109 Multidimensional Calculus 3:0:1:3

Polar coordinates; parametric equations; vectors and vector valued functions; functions of several variables; partial differentiation; double and triple integration; line and surface length vector operators and integral theorems; applications. *Prerequisite: MA 108 or equivalent.*

### MA 143 Introduction To Number Theory 3:0:0:3

Properties of integers and prime numbers, congruences, theorems of Fermat, Euler, Wilson, quadratic residues, diophantine equations. *Prerequisite: MA 102 or equivalent.*

### MA 153† Elements of Linear Algebra 3:0:0:3

Linear transformations, matrices and determinants, characteristic roots, diagonalization, introduction to vector spaces. *Prerequisite: MA 102 or equivalent.*

### MA 154† Elements of Abstract Algebra 3:0:0:3

Basic properties of groups, rings, fields, ideals, Euclidean rings, modules, field extensions. Galois theory, finite fields. *Prerequisite: MA 153.*

### MA 201-202 Applied Analysis each 3:0:0:3

Study of basic topics in analysis with emphasis on methods. Sequences, series, functions, uniform convergence, continuity, partial differentiation, extreme value problems with constraints, Riemann integrals, line integrals, improper integrals, integrals with parameters, transformations, Riemann-Stieltjes integral, uniform and absolute convergence of integrals. Beta, Gamma functions. *Prerequisites: MA 103 and MA 104 or MA 108 and MA 109.*

### MA 217 Complex Variables 3:0:0:3

Functions of a complex variable, derivatives, Cauchy-Riemann equations, integrals. Cauchy integral theory, power series, residue theory, conformal mapping. Schwarz-Christoffel transformation. *Prerequisites: MA 103 and MA 104 or MA 108 and MA 109.*

### MA 222 Introduction to Probability and Statistics 3:0:0:3

A one-semester course in probability and statistics which treats the basic theory of probability, random variables, expectation, and distribution theory. Statistical applications are made to parameter estimation, hypothesis testing, linear regression, and analysis of variance. Statistical software support is integrated into the course. *Prerequisite: MA 109 or equivalent.*

### MA 223† Introduction to Probability 3:0:0:3

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, or MA 109.*

### MA 224† Introduction to Mathematical Statistics 3:0:0:3

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.*

### MA 260† Vector Analysis and Partial Differential Equations 3:0:0:3

Vector algebra and vector calculus. Surface, line, and volume integrals. Theorems of Gauss, Green, Stokes. Curvilinear coordinates. Fourier series. Legendre polynomials and Bessel functions. Dirichlet and Neumann problems. Heat flow, wave motion, vibration problems. *Prerequisites: MA 103 and MA 104 or MA 108 and MA 109.*

### MA 341 Discrete Computational Structures I 3:0:0:3

Basic concepts of discrete mathematics. Logic and proof techniques. Sets, relations and functions. Introductory combinatorics. Directed and undirected graphs. Boolean Algebra. *Prerequisite: MA 101 or MA 106.*

### MA 342 Discrete Computational Structures II 3:0:0:3

Extends graph theory to network algorithms and covers material from finite state machines, computability, and formal languages. Introduces basic concepts of queuing theory. *Prerequisite: MA 101 or MA 106.*

### MA 358 Introductory Numerical Analysis 3:0:0:3

Polynomial interpolation and approximation of functions. Divided differences. Least-squares data fitting, orthogonal polynomials. Numerical differentiation and integration. Solution of nonlinear equations. Gaussian elimination, pivoting, iterative refinement, conditioning of matrices. Numerical solution of ordinary differential equations. *Prerequisites: MA 104 or MA 108 and some experience in computer programming.*

### MA 385-386 Reading Seminar In Mathematics I, II each 3:0:0:3

Reading, study and investigation of selected topics in mathematics. Problem discussions and presentations by participating students. *Prerequisite: departmental adviser's permission.*

Additional offerings in the area of statistics may be found under 500-number courses.



### MA 531-532 Applied Mathematics In Engineering and Science I, II each 2 1/2:0:0:3

Vector algebra and vector analysis. Determinants and matrices. Jordan normal forms. Eigenvalues of symmetric matrices by iteration. Applications to systems of differential equations, matrix exponential, Sturm-Liouville problems. Legendre polynomials and Bessel functions. Applications. Not acceptable for graduate credit in the Department of Mathematics. *MA 531 prerequisites: MA 108 and MA 109 or equivalent. MA 532 prerequisites: MA 531.*

**MA 541-542† Fundamentals of Discrete Mathematics I, II**  
each 2½:0:0:3

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)** 2½:0:0:3

Treatment of statistical methods and application to analysis of data, fitting of functions to data. Estimation of population parameters, t-tests, chi-square tests, rank tests. Not accepted for graduate credit in the Department of Mathematics. *Prerequisite: MA 107 or equivalent.*

**MA 552 Correlation-Regression-Variance Analysis** 2½:0:0:3

Discussion of models and computational schemes associated with correlation, regression coefficients, and variances. *Prerequisite: MA 224 or MA 551.*

**MA 575 Introduction to Differential Geometry** 2½:0:0:3

Differential geometry in the plane, introduction to transformation groups. Space curves and ruled surfaces. Tensors and exterior forms, manifolds and tensor fields. Theory of surfaces. Introduction to Riemannian geometry. *Prerequisites: MA 109 and MA 153 or equivalent.*

**ANALYSIS**

**MA 619-620 Advanced Calculus I, II**  
each 2½:0:0:3

Functions, sequences, bounds, limits. Properties of continuous functions. Mean value theorems, Taylor's series. Partial differentiation. Extreme value problems with constraints. Implicit functions. Transformations. Line integrals, Green's theorem. Transformation of double integrals. Uniform continuity. Theory of Riemann integral. Infinite series and power series. Uniform convergence. Improper integrals. *MA 619 prerequisites: MA 108 and MA 109 or equivalent. MA 620 prerequisite: MA 619.*

**MA 621 Real and Complex Analysis I** 2½:0:0:3

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, Lusin's theorem, product measure, Fubini theorems. *Prerequisite: MA 620 or equivalent.*

**MA 622 Real and Complex Analysis II** 2½:0:0:3

Rigorous development of theory of functions of a complex variable. 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 630 Elements of Complex Variables** 2½:0:0:3

Analytic functions of a complex variable. Complex numbers, differentiation and integration. Cauchy theorems, power series. Evaluation of integrals by residues. Conformal mapping, Schwarz-Christoffel transformations. *Prerequisites: MA 108 and MA 109 or equivalent (not open to students who have taken MA 217.)*

**MA 645 Theory of Ordinary Differential Equations** 2½:0:0:3

Ordinary differential equations. Existence and uniqueness theorems, linear systems, isolated singularities, self-adjoint eigenvalue problems, geometric theory of differential equations in the plane. *Prerequisite: MA 620 or equivalent.*

**MA 646 Theory of Partial Differential Equations** 2½:0:0:3

Partial differential equations. Cauchy-Kowalewski theorem, first-order differential equations, system of differential equations in two variables, characteristics and classification, hyperbolic, parabolic and elliptic systems, well-posedness. *Prerequisite: MA 645.*

**MA 658 Calculus of Variations** 2½:0:0:3

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, brachistochrons. *Prerequisite: MA 202 or MA 620.*

**MA 681-682 Functional Analysis I, II** each 2½:0:0:3

Hilbert spaces, Banach spaces, Banach algebras, linear operators, spectral theory, perturbation theory, completely continuous operators. Gelfand theory. Application to classical analysis. *MA 681 prerequisite: MA 703. MA 682 prerequisite: MA 681.*

**MA 703 Linear Algebra** 2½:0:0:3

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 108 and MA 109 or equivalent.*

**MA 705 Linear and Modern Algebra I** 2½:0:0:3

Basic algebraic structures, groups, rings, fields, integral domains, ideals, modules. Extensions of fields, Galois theory. *Prerequisite: MA 620 or equivalent.*

**MA 706 Linear and Modern Algebra II** 2½:0:0:3

Algebra of linear transformations, matrix theory, Jordan canonical form, Hermitian operators, unitary operators, normal operators, spectral theorem. Dual spaces, inner product spaces. *Prerequisite: MA 705.*

**MA 715-716 Advanced Topics in Algebra** each 2½:0:0:3

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

### GEOMETRY AND TOPOLOGY

**MA 754 Topological Methods in Analysis** 2½:0:0:3

Aspects of topological methods and applications to existence theorems in analysis. Use of fixed-point theorem and topological degree in study of properties of solutions of ordinary and partial differential equations. No previous courses in topology required. *Prerequisite: MA 202 or MA 620.*

**MA 755 Topology** 2½:0:0:3

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 775-776 Manifolds- Geometry and Differential Topology I, II** each 2½:0:0:3

Elementary theory of manifolds. Tangent space, mappings, submanifolds, fields, fiber bundles, Lie groups, homogeneous spaces. Elements of theory of connections, Riemannian geometry. Imbedded manifolds. Calculus of variations. Harmonic forms, complex manifolds, Morse theory. *MA 775 prerequisite: instructor's approval. MA 776 prerequisite: MA 775.*

### APPLIED MATHEMATICS

**MA 801-802 Special Topics in Applied Mathematics I, II** each 2½:0:0:3

Asymptotic expansions of definite integrals and of solutions to differential equations, perturbation theory, variational methods, non-linear vibrations, distributions, spectral representation of linear operators, relaxation methods, boundary-value problems. *MA 801 prerequisites: linear algebra and complex variables. MA 802 prerequisite: MA 801.*

**MA 813-817 listed Below under Probability, Statistics, Operations Research**

**MA 821 Numerical Analysis** 2½:0:0:3

Interpolation. Approximation of functions by polynomials. Fast Fourier transform. Numerical integration. Solution of non-linear equations. Iterative improvement of solutions of linear equations. Eigenvalues of matrices. Numerical solution of ordinary differential equations. *Prerequisite: MA 153 and some experience in computer programming.*

**MA 822 Numerical Solution of Partial Differential Equations** 2½:0:0:3

Stability, consistency, and convergence of finite-difference methods for initial-value problems. Implicit and explicit schemes. Method of lines. Alternating direction methods. Direct and iterative solutions of elliptic equations. Finite element methods. *Prerequisite: MA 821 or 358 and 153 and some experience in computer programming.*

**MA 833 Partial Differential Equations of Mathematical Physics** 2½:0:0:3

First-and second-order partial differential equations and systems of equations. Initial and boundary value problems. Fundamental solutions and Green's functions. Theory of characteristics. Eigenvalue problems. Rayleigh-Ritz and Ritz-Galerkin methods. Approximate and asymptotic methods. Nonlinear equations and applications. *Prerequisite: MA 202 or MA 620 or equivalent.*

**MA 837 Applied Matrix Theory** 2½:0:0:3

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 108 and MA 109 or equivalent. Also listed under EL 613*

**MA 846 Fourier and Laplace Transforms** 2½:0:0:3

Application of transform methods to partial differential equations of mathematical physics. Includes introduction to Wiener-Hopf technique. *Prerequisite: MA 630.*

### PROBABILITY, STATISTICS, OPERATIONS RESEARCH

**MA 813 Linear Programming** 2½:0:0:3

Theory and application of linear programming techniques. Simplex and revised simplex algorithms. Duality theory, dual simplex method, post-optimality analysis. Degeneracy. Transportation and assignment problems. Applications, problem formulation, computer solutions. *Prerequisite: MA 153. Also listed under IE 631*

**MA 815 Theory of Queues** 2½:0:0:3

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 2½:0:0:3

Graphs and subgraphs, connectivity, trees and girth, planarity, embeddings, n-connectivity and edge-connectivity, Hamilton graphs, matchings, factorization and covering, graphs and groups, graph isomorphism and reconstruction, colorings, map colorings, Ramsey and extremal graph theory, enumeration, connectedness in digraphs. Euler and Hamilton graphs, tournaments, networks. *MA 816 prerequisites: MA 108 and MA 109 or equivalent. MA 817 prerequisite: MA 816.*

**MA 853 Probability** 2½:0:0:3

Probability of events, distribution of random variables, joint distribution, transformations. *Prerequisites: MA 108 and MA 109 or equivalent, MA 223 or equivalent.*

**MA 855 Stochastic Process** 2½:0:0:3

Normal and stationary processes. Wiener processes, Poisson and renewal processes, Markov Processes. *Prerequisites: MA 853 or equivalent.*

**MA 861-862 Principles of Statistical Inference I, II** each 2½:0:0:3

Two semester sequence in statistical inference. Point and interval estimation of statistical parameters. Theory of statistical estimators. Fundamentals of statistical tests

of hypotheses. Second semester extends theory of tests of hypotheses, including sequential tests. Non-parametric methods in statistics. *MA 861 prerequisite: MA 224 or equivalent. MA 862 prerequisite: MA 861.*

**MA 863 Multivariate Analysis** *2 1/2:0:0:3*

Multivariate normal distribution, simple, partial, multiple correlation. Generalization of student's ratio, tests of significance of sets of means. Tests of general linear hypothesis. Some generalizations of analysis of variance. *MA 863 prerequisites: MA 862 and MA 153. MA 864 prerequisite: MA 863.*

**MA 865 Regression and Analysis of Variance** *2 1/2:0:0:3*

Linear regression of one or more independent variables. Least square estimates of regression coefficients. Gauss-Markov theorem. Confidence regions for and tests of hypothesis about regression coefficients. Test of general linear hypothesis. Multiple classification in analysis of variance. Power of F-test. Alternative models: I and II, mixed models, analysis of covariance and components of variance. *MA 865 prerequisites: MA 862 and MA 153. MA 866 prerequisite: MA 865.*

**MA 867 Non-Parametric Methods in Statistics** *2 1/2:0:0:3*

Statistical methods not bound by assumption of known parametric form of 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.*

**MA 873-874 Theory of Stochastic Processes I, II** *each 2 1/2:0:0:3*

Foundations of stochastic processes. Kolmogorov's extension theorem. Properties of sample paths. Conditional expectation. Martingales. Classes of stochastic processes, Gaussian processes, Markov processes, others. Second-order properties. Stationary processes. Applications. *MA 873 prerequisite: MA 872 or equivalent. MA 874 prerequisite: MA 873.*

**MA 881-882 Statistical Analysis of Time Series I, II** *each 2 1/2:0:0:3*

Careful study of tractable models for statistical analysis of scalar time series. Models treated: (1) "error plus trend" models and (2) stationary stochastic process models with special emphasis on autoregressive models. Estimation, tests of hypotheses and multiple-decision procedures for these models, spectral representation and filtering, estimation of spectral density. *MA 881 prerequisites: MA 153, MA 854 and MA 862. MA 882 prerequisite: MA 881.*

**READING, PROJECT, THESIS, DISSERTATION**

**MA 941-944 Reading in Mathematics I-IV** *each 2 1/2:0:0:3*

Courses intended primarily for students who have completed two years of full-time graduate study and who wish to do research in a specialized area. Reading done under guidance of faculty members and devoted mainly to scholarly papers. *Prerequisite: permission of department.*

**MA 958-959 Selected Topics in Advanced Mathematics I, II** *each 2 1/2:0:0:3*

Same course description as MA 955-956 except for credit structure. *Prerequisite: permission of department.*

**MA 997 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 adviser required. Reregistration fee, any part: 3-unit charge. *Prerequisite: degree status.*

**MA 999 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.*

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 † following the course number (e.g., MA 223).

**FACULTY**

**Deane Yang**, Professor of Mathematics and Head of Department  
B.A., University of Pennsylvania. Ph.D., Harvard University  
*Differential geometry; nonlinear partial differential equations; overdetermined systems of partial differential equations*

**Burton Lieberman**, Associate Professor of Mathematics and Administrative Officer  
B.A., Harvard University; M.S., Ph.D., New York University  
*Differential equations; stochastic processes; statistics, sport science*

**George Bachman**, Professor of Mathematics  
B.E.E., M.S., Ph.D., New York University  
*Fields and Valuations; Banach algebras; topological measure theory*

**Emeric Deutsch**, Professor of Mathematics  
B.S., Pedagogical Institute of Timisoara (Romania); M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Matrix theory; functional analysis*

**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*

**Richard Mandelbaum**, Professor of Mathematics; B.S., Rensselaer Polytechnic Institute; M.A., Ph.D., Princeton University  
*Algebraic geometry; four dimensional topology*

## MATHEMATICS AND STATISTICS

**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  
*Mathematical programming, computer graphics, artificial intelligence*

**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*

**Lesley Sibner**, Professor and Head of Mathematics  
B.S., CCNY; M.S., Ph.D., New York University  
*Partial differential equations; global analysis*

**Georges Weill**, Professor of Mathematics; Lic. Math., Dr.Sc., University of Paris (France);  
Ph.D., University of Southern California  
*Complex analysis; global analysis; partial differential equations*

**Erich Zauderer**, Associate Professor of Mathematics  
B.S., Yeshiva College; M.S., Ph.D., New York University  
*Nonlinear wave propagation; partial differential equations; diffraction problems*

**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*

**Joel Rogers**, Associate Professor of Mathematics  
B.S., Ph.D., Massachusetts Institute of Technology  
*Partial differential equations; fluid mechanics; numerical methods*

**El-Bachir Yallaoui**, Instructor of Mathematics  
"Diplome d'Etudes Superieures", M.S. University de Setif, Algeria; Ph.D., Polytechnic University  
*Real and Functional Analysis*

### ADJUNCT FACULTY

**Daniel Drance**, Lecturer  
M.S., State University of New York, Stony Brook

**Kamal Hajallie**, Lecturer  
B.S., N.Y. Institute of Technology; M.S., Fordham University; Ph.D., Polytechnic University

**Carl Gogolak**, Lecturer  
M.A., Fordham University; Ph.D., Polytechnic University

**Dale Siegel**, Lecturer  
B.S., M.S., Ph.D., Polytechnic University

**Walter Vohs**, Lecturer  
B.S., SUNY Maritime College; M.S., 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.S., Brooklyn College; M.S., New York University  
*Network theory; graph theory*

**Heinrich Guggenheimer**, Professor Emeritus; Dipl., Dr.Sc., Swiss Federal Institute of Technology-Zurich (Switzerland)  
*Differential equations; geometry-convexity*

**Leon 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*

**Harry Hochstadt**, Professor Emeritus; B. Chem. E., Cooper Union; M.S., N.Y. University; Ph.D., N.Y. University  
*Differential equations; spectral ehtory; functional analysis*

**Andrew J. Terzuoli**, Professor Emeritus  
B.S., Brooklyn College; M.S., New York University  
*Probability; statistics*

# MECHANICAL ENGINEERING

The undergraduate degree in mechanical engineering is offered on both the Brooklyn and Long Island campuses, and may be taken by full-time students at either location. Some laboratories are shared in the senior year. Co-op students can be accommodated. Part-time students take the same classes as full-time students; there is no evening program. Transfer students are welcome. There are also pre-planned programs or articulation agreements with several schools which ease the transfer. Consult the Admissions Office for details.

Graduate degrees in mechanical engineering are offered on the MS and PhD levels. For each level, the student may choose a specialty area in thermal and fluid sciences, mechanical analysis and design, or controls and robotics. By selecting certain electives, the student may also have a focus in manufacturing within any of these three specialties.

All mechanical engineering graduate degrees are offered to both full-time and part-time students at the Brooklyn campus. The MS is offered on the Long Island Campus for part-time students. PhD students may work on their dissertation at the campus most suited to the adviser and the topic.

## THE MECHANICAL ENGINEERING PROFESSION

Mechanical engineering is a dynamic and evolving profession. Mechanical engineers develop the physical systems and devices that modern society needs or wants from automobiles to air conditioning, robots to power plants, people movers to artificial limbs, and rocket engines to communications satellites. It has a long tradition of leadership in helping to develop the natural environment while breaking the ground in such areas as resource conservation through better maintenance techniques, improved efficiency of energy-consuming devices

such as integrated circuits, development of codes for a safer technological environment, new energy sources, and co-generation.

While undergraduate and graduate programs in mechanical engineering are designed primarily to develop talents in these areas, graduating students eventually apply their training to the additional diversified fields of bioengineering, manufacturing, astronautics, systems engineering, management, and law. As students mature and realize their abilities, their professional lives may center on engineering research, government, business, or education.

## UNDERGRADUATE PROGRAM

All Polytechnic undergraduates now begin their engineering education in the freshman year, with the EG101-102 sequence. They are also introduced to programming methodology (CS200) and to the physical sciences and to a five-semester sequence of mathematics. The table on the next page shows the typical four-year curriculum in mechanical engineering.

Mechanical engineering students begin courses in their major in the beginning of the sophomore year, with courses in engineering graphics, mechanics, and mechanical properties of materials. In the junior year, the students take an instrumentation course (ME321) and take core courses which fall into three areas: thermal/fluids, mechanical analysis and design, and controls. There is a strong emphasis on design, beginning in the freshman year and continuing through the capstone senior design sequence. Several courses require design projects. There is also a strong emphasis on hands-on lab experience, with a total of six credits of ME laboratories (ME324, ME273, ME351-352) plus computational labs in graphics and in finite element methods.

To provide a broader education and understanding of the world, twenty-seven credits of study in humanities and social sciences are required. Several electives are included, as shown in the typical program. Throughout these courses and in several designated "writing intensive" courses in the major, students are also required to use and refine their communication skills. Tomorrow's leaders must be truly educated and must also be able to express themselves.

Students are encouraged to participate in the ASME and/or SAE student chapters, and to make use of departmental space for study and interaction with other students in the program. During the past several years, students from freshman to senior in several disciplines worked together on the SAE Formula-One Car Project which was entered into national competition in 1992 and 1993. Teamwork is encouraged in these projects and in the departmental labs.

Mechanical engineering students have four technical electives available to them, of which two must be taken from the following courses:

ME232	Fluids II
ME204	Design of Energy Transfer and Conversion Systems
ME272	Stress II
ME261	Vibrations
ME323	Advanced Controls and Robotics

In recent years, other available electives included courses in HVAC, powerplants, internal combustion engines, manufacturing processes, engineering economy, systems simulation, quality control and assurance, and design for manufacturability. By proper selection of electives, students may concentrate in manufacturing or in aerospace engineering.

Students are encouraged to work closely with the academic adviser, using

---

This typical program is for students entering in September 1993 and later. Students enrolled prior to September 1993 should consult the departmental brochure covering their year.

## MECHANICAL ENGINEERING

the departmental brochure entitled "Advising Procedures and Record for the BS(ME)". This brochure includes checklists on the technical and humanities/social science electives, to assure that all degree requirements are met.

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

### SPECIAL DEPARTMENTAL REQUIREMENTS

Seniors with GPA's of 3.5 or better may take honors work (ME381-2). Seniors with good academic standing may take certain graduate courses as electives with the departmental adviser's approval.

In addition to the University requirement of a 2.00 GPA for graduation, ME students must also earn a 2.00 overall GPA in their ME courses (i.e. all those with "ME" prefixes in the "Typical Program of Study", plus the technical electives).

Students must have a "C" average in three sophomore-level courses (ME111, ME112, ME121) before proceeding to junior-level courses. Students must have a "C" average in three junior-level courses (ME201, ME202, ME231) before proceeding to senior-level courses. Those not satisfying these requirements must repeat the courses which earned less than a "C" grade before proceeding.

Students on academic probation are usually permitted to preregister for the next semester, but are obliged to consult with the ME adviser after their grades are posted, and before the beginning of classes.

### TRANSFER STUDENTS

Qualified graduates of two-year pre-engineering programs, such as those offered at several community colleges and four-year liberal arts colleges, may often fulfill the requirements for the B.S. degree in mechanical engineering in two additional years. Space does not allow illustrations of the way in which this can be done, due to the variations from college to college. However, the undergraduate advisers are familiar with our

past practice with several colleges and able to guide the prospective student. With some colleges, there are formal articulation agreements and typical programs of study.

Students who have some coursework toward a degree may also apply for transfer credit upon application to Polytechnic. In all cases, transfer credit is granted based upon equivalence to Polytechnic courses. The process is expedited by previous decisions, and past transfer credit granted to students from the same college is good indicator for prospective students. However, the adviser must be consulted in all cases for a current decision; content of courses do change over the years at Polytechnic and the other colleges, and it is this which determines decisions in each case.

Transfer students are strongly encouraged to have a meeting with the undergraduate adviser separate and apart from the registration process, so that a proper evaluation may be done. The Admissions Office does have information on past decisions for a given college, or can arrange a meeting with the departmental undergraduate adviser.

Graduates of technology programs may be able to fulfill the requirements for the B.S. degree in mechanical engineering in two to three and one-half years depending upon the scope and level of their previous education. The same is true for graduates of practical engineering and other such programs in various countries. Consult with an undergraduate adviser for details.

### MANUFACTURING AND INDUSTRIAL ENGINEERING COURSES

Students interested in undergraduate courses in manufacturing may take such courses as advanced controls and robotics (ME323), manufacturing processes (ME340/MT340), and solid modeling and design (ME332). Qualified students may take graduate courses in manufacturing systems engineering (MN788) or design for manufacturability (MN792). There are also several industrial engineering undergraduate courses listed in this section of the catalog, in engineering economy, system simulation, robotics applications, quality control and management, and facility design.

## TYPICAL PROGRAM OF STUDY FOR THE BS(ME)

### FRESHMAN YEAR

#### First Semester

EG 101	<i>Intro to Engrng.</i>	3
MA 106	<i>Calculus I</i>	4
CM 101/111	<i>Gen Chem I</i>	3
CS 200	<i>Pgmng Methodology</i>	3
HU 101 or 103		3
SL 101	<i>Freshman Seminar</i>	0
		<u>16.0</u>

#### Second Semester

EG 102	<i>Intro to Eng Design</i>	3
MA 107	<i>Calculus II</i>	4
CM 102/112	<i>Gen.Chem II</i>	3
PH 107	<i>Mechanics</i>	3
HC 200 or SS 104		3
		<u>16.0</u>

### SOPHOMORE YEAR

#### First Semester

MA 108	<i>DE's &amp; Num Methods</i>	3
PH 108/118	<i>Elect, Magnet, Fluids</i>	3.5
HC 200 or SS 104		3
ME 111	<i>Mechanics I</i>	3
MT 305	<i>Mech Prop of Materials</i>	3
ME 101	<i>Graphics</i>	2
		<u>17.5</u>

#### Second Semester

MA 109	<i>Multidimen Calculus</i>	3
PH 109/119	<i>Waves, Optics, Thermo</i>	3.5
	<i>HU/SS Elective</i>	3
HU 110	<i>Prof Report Writing</i>	3
ME 112	<i>Mechanics II</i>	3
ME 121	<i>Mech. of Materials</i>	3
		<u>18.5</u>

### JUNIOR YEAR

#### First Semester

	<i>HU/SS Elective</i>	3
	<i>Math Elective</i>	3
ME 271	<i>Stress I</i>	3
ME 201	<i>Thermodynamics I</i>	3
ME 231	<i>Fluids I</i>	3
ME 321	<i>Instrumentation</i>	3
		<u>18.0</u>

#### Second Semester

	<i>HU/SS Elective</i>	3
ME 202	<i>Thermodynamics II</i>	3
ME 203	<i>Heat Transfer</i>	3
ME 301	<i>Synth of Mech Sys</i>	3
ME 322	<i>Automated Control</i>	3
ME 324	<i>Instru/Cntl Lab</i>	3
		<u>18.0</u>

**SENIOR YEAR**

**First Semester**

	<i>HU/SS Elective</i>	3
ME 351	<i>Thermal/Fluids Lab I</i>	1
ME 302	<i>Machine Elements</i>	3
ME 273	<i>Stress/Mach Lab</i>	1
ME 361	<i>Senior Project I</i>	2
	<i>Technical Elective</i>	3
	<i>Technical Elective</i>	3
		<u>16.0</u>

**Second Semester**

	<i>HU/SS Elective</i>	3
ME 352	<i>Thermal/Fluids Lab II</i>	1
ME 341	<i>Finite Elements</i>	4
ME 362	<i>Senior Project II</i>	2
	<i>Technical Elective</i>	3
	<i>Technical Elective</i>	3
		<u>16.0</u>

Two of the technical electives must come from:  
ME 272, ME 232, ME 323, ME 261, ME 204

Total Credits 136

**GRADUATE PROGRAM**

Programs of study leading to the MS and PhD degrees in Mechanical Engineering are available in each of three specialty areas:

- Thermal and Fluid Sciences
- Mechanical Analysis and Design
- Systems, Controls, and Robotics

Within each of these specialties, a student may choose to concentrate some of the electives in manufacturing engineering.

A bachelor's degree and good academic record in mechanical engineering from a suitable college or university is generally required for admission to the graduate program. Applicants with degrees from fields other than mechanical engineering may be admitted, but have to undertake additional studies to achieve a comparable background. The courses required to achieve this are specified as part of the admission evaluation or first advising session. Undergraduate courses specified for this purpose cannot count toward credits needed for the degree.

Graduate programs are subject to the prior approval of the graduate adviser designated by the department. All students are required to have a GPA of 3.00 or better in each of the following: in all graduate courses taken at Polytechnic; in

all courses submitted for the ME degree; in all guided studies (readings, projects, thesis, dissertation).

**REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE**

The requirements for the MS degree in mechanical engineering are suited to the applicant's specialty, which is specified by the student in the admissions process or the first advising session.

Full-time MS students are expected to undertake a research project or thesis as part of the program.

Students must take at least 27 units of the MS Program at Polytechnic. No more than a total of nine units may be attributed to transfer and readings courses. Validation credit is not allowed, but specific requirements may be waived (and an appropriate substitute designated) by the graduate adviser, based upon the student's prior studies or experience.

Studies for the MS must be completed within a four year period, unless there is a formal leave of absence approved prior to the period for which the studies are interrupted.

**The degree requirements are:**

ME 600	<i>Applied Computational Methods</i>	3
ME 700	<i>Finite Elements</i>	3
ME 991-2	<i>Seminar in Mechanical Engineering</i>	..
	<i>Required for Specialty Area (see below)</i>	12
	<i>Electives, approved by graduate adviser</i>	18
		<u>36</u>

The 18 credits of electives must include at least 6 units within the ME Program and no more than 12 units from non-ME courses<sup>1</sup>. Students are encouraged to take at least one graduate course in mathematics as part of the non-ME courses. Full-time students must take project or thesis work totalling from 6 to 12 units and may take no more than 9 units of non-ME courses<sup>4</sup> as electives. All courses and program details are subject to adviser approval.

**Thermal and Fluid Sciences**

**The required courses are:**

ME 601	<i>Thermodynamics I</i>	3
ME 605	<i>Heat Transfer</i>	3
ME 610	<i>Fluid Dynamics</i>	3
ME 706	<i>(Convection) or ME711 (Viscous Flow)</i>	3

Common ME electives include conductive heat transfer, HVAC, and experimental methods in thermal/fluid science, thermal issues in manufacturing processes, vibrations, and discrete feedback control.

**Mechanical Analysis and Design**

**The required courses are:**

ME 621-22	<i>Stress I-II*</i>	6
ME 644-45	<i>Vibrations I-II</i>	6

Common ME electives include fracture mechanics, stress analysis of composite materials, elasticity, thermodynamics, and discrete feedback control.

**Systems, Controls, and Robotics**

**The required courses are:**

ME 660	<i>Discrete Time Feedback Control</i>	3
ME 661	<i>Sensors Based Robotics</i>	3
EL 610	<i>Linear Systems (ME670)</i>	3
EL 725	<i>State Space Design for Linear Control Systems (ME671)</i>	3

Common ME electives include vibrations, adaptive control, neural networks, fracture mechanics, thermodynamics, and heat transfer.

**MANUFACTURING**

Students in any one of the three preceding specialties may concentrate some of their electives in manufacturing. The following courses are strongly recommended:

IE 611	<i>Quality Control and Improvement</i>
MN 788	<i>Manufacturing Systems Engineering</i>

plus at least a third elective selected from:

ME 717	<i>Thermal Design of Electronics Systems</i>
ME 718	<i>Thermal Issues in Manufacturing Processes</i>

Other relevant courses may be approved by the graduate adviser.

<sup>1</sup> No more than 9 units in the "Systems, Controls, and Robotics" specialty

<sup>4</sup> No more than 6 units in the "Systems, Controls, and Robotics" specialty

<sup>5</sup> Students with good preparation in stress analysis are encouraged to seek a waiver of these courses, and an appropriate substitution. One such substitution is Elasticity I-II (ME721-722).

## REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE

The PhD Degree is a terminal degree beyond the MS, focused on engineering research. Students are expected to advance the state of the art in their specialty by original and creative work.

An MS degree in mechanical engineering with a specialization in one of the three departmental areas (thermal and fluid sciences, mechanical analysis and design, systems/controls/robotics) is required for admission to the PhD Degree Program. A grade point average (GPA) of 3.5 or better in the MS work is generally required for admission.

In cases in which it is unclear that the required MS specialization has been satisfied, the MS degree requirements of the preceding section shall be used to define the necessary preparation. The same criterion shall be used when the MS degree is in other engineering disciplines.

The department has a "Set of Guidelines for the PhD Program in Mechanical Engineering" which describe the requirements related to qualifying examinations, dissertation proposals, guidance committees, dissertation defense, and other relevant matters. Polytechnic's Office of Research and Graduate Affairs has information on admission to candidacy, dissertation preparation, and other matters. Students are encouraged to obtain copies of these documents.

### The General Requirements for the PhD Degree are:

	<b>Units</b>
Major work related to specialty	30-36
Approved courses in two minor areas*	24-30
PhD Dissertation (ME 999)	24-30

ME 991-2 Seminar in ME (each semester)	0 90
--	---------

Studies for the PhD Degree must be completed within a five year period following the MS degree or the date of admission, whichever is later, unless there is a formal leave of absence approved prior to the period for which the studies are interrupted.

Once the dissertation is begun, the student must register for at least three units of ME999 in each Fall and Spring

semester. Actual registration should reflect the pace of the work and the activity of the student. An exception to the minimum registration requirement may be made in the last semester of registration, if that semester is primarily devoted to finalizing the work and dissertation document. Dissertation grades of "U" in two consecutive terms will be cause to reconsider whether the student will be permitted to continue doctoral work.

The ME991-2 registration is required during *each semester* of the PhD Degree studies. The purpose is to assure exposure to current work in the field, and participation in the ME Program.

## UNDERGRADUATE COURSES

### ME 101 Engineering Graphics

1:3:0:2

Sketching, drawing, and computer-aided drafting. Projection theory: multiview, axonometric, oblique. Auxiliaries, sections, isometrics, dimensions, fasteners, detail and assembly drawings. Introduction to blueprint reading. Overview of CIM, and CAD integration with other CIM concepts. Design project incorporating developed skills in visualization, drawing techniques, standards, and CAD. *Prerequisites: Introduction to Engineering Design (EG 102).*

### ME 111 Mechanics I

3:0:0:3

Three-dimensional vector treatment of the static equilibrium of particles and rigid bodies. Equivalent force and couple systems. Distributed force systems. Static analysis of trusses, frames and machines. Friction, impending motion. Methods of virtual work. *Prerequisites: Mechanics (PH 107); Calculus II (MA 107).*

### ME 112 Mechanics II

3:0:0:3

Three-dimensional treatment of the kinematics 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: Mechanics I (ME 111).*

### ME 121 Mechanics of Materials

3:0:0:3

Stresses and strains in tension, torsion, and bending members. Statically determinate and indeterminate structures. Deflections of beams. Column instability. *Prerequisites: Mechanics I (ME 111); Mechanical Properties of Materials (MT 305).*

### ME 201 Thermodynamics I

3:0:0:3

Properties of pure substances; concepts of work and heat; closed and open systems. The fundamental laws of thermodynamics. Carnot and Clausius statements of the 2nd law; entropy and entropy production; heat engines, refrigerators, heat pumps; efficiencies, coefficients of performance. *Prerequisites: Waves, Optics, Thermodynamics (PH 109); DE's & Numerical Methods (MA 108).*

### ME 202 Thermodynamics II

3:0:0:3

Continuation of ME 201. Irreversibility and availability. Power and refrigeration cycles. Maxwell's equations and other thermodynamic relations. Properties of mixtures; air-conditioning. Energy and equilibrium aspects of chemical reactions; flame temperatures. Introduction to phases and chemical equilibrium. *Prerequisites: Thermodynamics I (ME 201).*

### ME 203 Heat Transfer

3:0:0:3

Fundamentals of conduction and radiation heat transfer. Analysis of multi-dimensional geometric for the conduction mode. Introduction to radiation circuit concepts. Analysis of no flux walls and radiation balance. Gas radiation consideration. *Prerequisite: Thermodynamics I (ME 201); Fluids I (ME 231).*

### ME 204 Design of Energy Transfer and Conversion Systems

3:0:0:3

Introduction to boundary layer and development of Nussault number and Reynolds number relationships. Laminar and turbulent heat transfer aspects. Fundamentals of heat exchanger design.

\* The minors are each 12-15 units of graduate study, and are generally chosen to strengthen the student's ability to pursue the dissertation work. They are developed in concert with the graduate adviser and/or dissertation adviser. At least one minor must be within the ME Program. See the "Set of Guidelines" for illustrations of approved minors.

Parallel, counterflow, and crossflow arrangements. Shell and tube considerations. Design projects. *Prerequisites: Thermodynamics II (ME 202); Heat Transfer (ME 203).*

### ME 212 Heating, Ventilation & Air Conditioning 3:0:0:3

Review of thermodynamic principles, psychrometric chart and psychrometric analysis, comfort air conditioning and indoor air quality, heating and cooling system, HVAC system design and equipment selection. *Prerequisite: Heat Transfer (ME 203).*

### ME 213 Transport Processes 3:0:0:3

Extension of principles developed in ME 201, ME 231, and ME 203. Energy release and momentum, heat and mass transfer process. Unified treatment using transport phenomena methods. *Prerequisites: Heat Transfer (ME 203)*

### ME 231 Fluids I 3:0:0:3

Introduction to fluids, kinematics, hydrostatics, thermodynamics. Basic conservation laws in integral control volume, conservation of mass, momentum, angular momentum, and energy. Bernoulli equation. Introduction to differential analysis of fluid motion for internal and external flows. *Prerequisites: Elec, Magnet, Fluids Lab (PH 108/118); DE's & Numerical Methods (MA 108); Multidimensional Calculus (MA 109).*

### ME 232 Fluids II 3:0:0:3

Dimensional analysis and similitude. Flows in pipe networks and ducts, head losses, friction factors. Flow measurement. Fluid machinery, velocity polygon analysis, performance characteristics, combination with flow systems. Introduction to compressible flow, steady one-dimensional flow in nozzles, normal shocks. *Prerequisite: Fluids I (ME 231).*

### ME 243 Internal Combustion Engines 3:0:0:3

Introduction and definitions, engine operating characteristics. Thermodynamics of internal combustion engines. Thermodynamics of combustion. Combustion in spark ignition and compression ignition engines. Design for performance and efficiency. Pollutant formation and controls, emissions tests. *Prerequisite: Thermodynamics I (ME 201)*

### ME 261 Vibrations 3:0:0:3

Undamped and damped vibrating systems. Free vibrations. Harmonic, periodic, and transient forces. Forced responses. Accelerometers. Two and multi-degree of freedom systems. *Prerequisites: Mechanics II (ME 112).*

### ME 271 Stress I 3:0:0:3

Concepts of the classical linear theory of elasticity. Stress, strain, transformations equations, equilibrium equations, compatibility, stress-strain relations, boundary conditions, superposition, St. Venant's Principle, application to extension and bending bars of arbitrary cross section. Unsymmetric bending of beams, calculation of stresses and displacements. Shear flow and shear beams of open and closed thin-walled cross section. *Prerequisites: Mechanics of Materials (ME 121); DE's & Numerical Methods (MA 108).*

### ME 272 Stress Analysis of Mechanical Components 3:0:0:3

Castigliano's method for trusses, beams, and frames. Thick-walled cylinders, shrink fits. Beams on elastic foundations. Thermal stresses in rotors. Torsion of mechanical elements. Laboratory experiment related to determining shear centers, stress concentrations by photoelasticity. *Prerequisite: Stress I (ME 271).*

### ME 301 Synthesis of Mechanical Systems 3:0:0:3

Kinematic analysis and design of linkages. Velocity and acceleration images. Instantaneous centers. Design of cams, gears trains. Geometric and algebraic methods of synthesis for path and function generators. *Prerequisite: Graphics (ME 101); Mechanics II (ME 112).*

### ME 302 Analysis and Design of Machine Elements 3:0:0:3

Applications of basic principles in-depth analysis and design selected machine elements: brakes, clutches, springs, screws, wear, boundary and hydrodynamic lubrication. Term design of project. *Prerequisites: Synthesis of Mechanical Systems (ME 301); Stress I (ME 271).*

### ME 321 Instrumentation 3:0:0:3

Measurement Statistics: standard deviation, curves of regression, accumulation of errors. Electrical measurements and devices. Instrument systems and compo-

nents: transduction of mechanical information into analog and digital signals; signal processing and filtering devices; readout devices. Static and dynamic measurements of mechanical components and systems; computer simulation studies. Introduction to digital logic. Computer Interfacing. *Prerequisites: Elec, Magnet, Fluids Lab (PH 108/118); DE's & Numerical Methods (MA 108).*

### ME 322 Automated Controls 3:1:1:0:4

Feedback and development of control systems. Transfer functions. Block and signal flow diagram. Responses to aperiodic and periodic excitations. Error considerations. Stability; Routh-Hurwitz criterion, root locus. Bode-plot techniques. Laboratory: experiments in instrumentation and controls. *Prerequisite: Instrumentation (ME 321).*

### ME 323 Advanced Controls and Robotics 2:1:0:3

Spatial descriptions and operators. Transformation of vectors. Link description. Link parameters. Algebraic and geometric solution of inverse kinematics. Velocities and static forces. Newton-Euler dynamic formulation. Manipulator dynamics in Cartesian and Joint space. Path description and generation. The control problem for manipulators. The hybrid position: force control problem. *Prerequisite: Automated Controls (ME 322).*

### ME 324 Instrumentation/Controls Laboratory 1:3:0:3

Electrical measurements. Passive & active filters. Computer interfacing and simulation. Temperature sensing and control. Air flow sensing. Strain, force and acceleration measurement. DC-motor modeling and control. *Co-requisite: Automated Controls (ME 322).*

### ME 332 Solid Modeling and Analysis 2:3:0:3

Study of 3D Modeling techniques; Application of these techniques using CAD workstations; constructive solid geometry and boundary rep methods to generate 3D objects and assemblies; mass and inertial property analysis; finite element analysis; interference checking and kinematic analysis. An independent design project at the end of this course requires application of all these techniques. *Prerequisites: Graphics (ME 101).*

## MECHANICAL ENGINEERING

### ME 340 Manufacturing Process

2½:1½:0:3

Properties of materials relating of fabrication methods. Casting. Metal cutting mechanics, cutting fluids, thermal and vibrational aspects of machining. Machinability criteria. Deformation processing, hot and cold, mechanics of deformation. Joining and welding. Unconventional processing. Electrochemical and electrodischarge machining. *Prerequisite: Mechanical Properties of Materials (MT 305).*

### ME 341 Finite Elements

3½:1½:0:4

The finite-element method as it applies to continuum-type, boundary-value problems; introduction to calculus of variations and weighted residuals; Ritz vs. Galerkin; one and two-dimensional simplex and complex elements. Special purpose programs for obtaining numerical solutions to differential equations which govern engineering problems in structural mechanics, elasticity, heat transfer, and fluid flow. *Prerequisites: Stress I (ME 271); Heat Transfer (ME 203)*

### ME 351 Heat Transfer Laboratory I

½:1½:0:1

Instrumentation principles. Experiments related to thermodynamics, fluid mechanics, and heat transfer. *Prerequisites: Fluid Mechanics I (ME 231); Instrumentation/Controls Lab (ME 324); Thermodynamics II (ME 202).*

### ME 361 Design Project I

0:6:0:2

Seniors are required to take a two course sequence in which they are exposed to principles of design and the design process, and then undertake one or more specific designs. The designs are generally specified by the student from a list of available projects. Students work in small groups. Written and oral status reports are required. The two course sequence often involves experienced design engineers from industry. *Prerequisite: Senior year status.*

### ME 362 Design Project II

0:6:0:2

The second semester of the senior design sequence. Written and oral presentations are required, and are part of the grading, as is the design product itself. The assigned grade is applied to both ME 361 and ME 362. *Prerequisite: Senior year status.*

### ME 391-392 Selected Topics I, II

1:6:0:3

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.

## INDUSTRIAL ENGINEERING COURSES

These courses are under the administrative control of the department, and are available as electives in M.E. and other programs.

### IE 300 Engineering Economy

3:0:0:3

Economic and financial considerations in engineering decisions. Decision criteria under certainty, risk, uncertainty. Cost concepts, financial calculations, capital sources, accounting data, depreciation. Comparison of alternatives by annual cost, present worth and discounted cash flow methods. Minimum cost and maximum profit determination, replacement and economic life, breakeven analysis, effect of taxes, intangible factors. *Prerequisite: junior standing.*

### IE 311 Quality Control and Quality Assurance

3:0:0:3

Introduction to the concepts of the cost of quality, quality assurance, quality process control, and total quality management. Emphasis on process management and control. Control charts and their use; the concept of "out of control"; charts based upon variables and charts based upon attributes. Specifications, and tolerances. Acceptance sampling by lots, including concepts of producers and consumers risks. Course project required. *Prerequisite: MA 223.*

### IE 321 Facility Planning and Design

3:0:0:3

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 computer-

ized layout planning, materials handling systems, evaluation and improvement of facility productivity. *Prerequisite: MA 102.*

### IE 342 Robotics Applications

2½:1½:0:3

Applied robotics and the cost-effective integration of robots into manufacturing processes. The course will cover total systems, robotic cell 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. *Prerequisites: junior standing.*

### IE 380 System Simulation

2:3:0:3

Modeling and simulation of discrete stochastic systems, including random variables and statistical phenomena. Case studies of simulation applications. Intensive applications of PC-based simulation software packages. Economic factors supporting simulation techniques. Students develop, run, and experiment with several simulation models. *Prerequisites: MA 224.*

## GRADUATE COURSES

### ME 600 Applied Computational Methods

2½:0:0:3

Computational methods used in formulation and solving problems that occur in engineering. Methods of interpolation, numerical differentiation and integration, solution of linear and non-linear equations and eigenvalue problems. Finite difference methods. Particular attention to continuum techniques, e.g., Rayleigh-Ritz, Galerkin, and Collocation. **Also listed as AE 623.**

### ME 700 Finite Elements

2½:0:0:3

Derivation of element stiffness matrices. Construction of general stiffness matrices in global coordinates. Application to problems in plane stress, plates, and shells under static and dynamic loads.

Applications in thermal, heat transfer, and fluid mechanics. Emphasis on problems involving analysis of systems with many unknowns. *Prerequisite: ME 600.*

## THERMAL AND FLUID SCIENCES

### ME 601 Thermodynamics I

2/1:0:0:3

Availability functions, general thermodynamic relations, equations of state, general thermodynamic equilibrium criteria. *Prerequisite: ME 202 or equivalent.*

### ME 605 Heat Transfer 2/1:0:0:3

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. *Prerequisites: ME204 or equivalent.*

### ME 610 Fluid Dynamics 2/1:0:0:3

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: ME 232 or equivalent.*

### ME 701 Thermodynamics II 2/1:0:0:3

Continuation of ME 605. Applications of thermodynamic equilibrium criteria to various problems, including chemical reactions. *Prerequisite: ME601.*

### ME 706 Convective Heat Transfer

2/1:0:0:3

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: ME 605.*

### ME 707 Conductive Heat Transfer

2/1:0:0:3

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: ME 605.*

### ME 708 Radiative Heat Transfer

2/1:0:0:3

Fundamentals of radiative mechanisms of energy transfer. Definitions of basic qualities. Equations of transfer, radiative heatflux vector and conservation equations. Properties of surfaces and participating media. Applications to engineering systems. *Prerequisite: ME 605.*

### ME 711 Viscous Flow and Boundary Layers

2/1:0:0:3

Introduction to molecular and macroscopic transport, concepts of stress and strain, and derivation of the Navier-Stokes equations. Application to problems of diffusion, boundary layers and slow motion. Analytic and numerical methods are presented. *Prerequisites: ME 610.*

### ME 712 Turbulent Flow 2/1:0:0:3

General theories of turbulence, basic concepts, transition, homogeneous turbulence, analysis of turbulent shear flows, turbulent heat and mass transfer, experimental methods. *Prerequisites: ME 610.*

### ME 713 Compressible Flow

2/1:0:0:3

Subsonic, transonic, and supersonic flows over two dimensional and axisymmetric bodies. Shock wave development in both one-dimensional unsteady and two-dimensional steady flow systems. Internal and external flows are considered. *Prerequisite: ME 601; ME 610.*

### ME 715 Computational Methods in Thermal-Fluid Sciences

2/1:0:0:3

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. *Prerequisites: ME 600 and ME605 or ME610. Also listed under AE 732.*

### ME 716 Experimental Methods in Thermal-Fluid Sciences

2/1:0:0:3

Integrated survey of the principal techniques and instrumentation used for obtaining experimental data in thermal-fluid sciences. Topics include: calibrations, accuracy, generalized performance

characteristics, various devices for measuring flow, velocity, pressure, temperature, heat flux, computerized data acquisition, planning experimental programs, parametric mapping, and noise in measuring systems. *Prerequisite: ME 605 or permission of graduate adviser.*

### ME 717 Thermal Design of Electronics Systems for Performance and Reliability

2/1:0:0:3

Thermal modeling and simulation of electronic equipment and systems, forced and natural air cooling, cooling with water and other liquids, cryogenic cooling, use of cooling correlations, approximate numerical formulations, fan characteristics, fan and disc acoustic noise, chip thermal profiles, thermal influence on the reliability of semiconductor circuits. *Prerequisite: ME605 or permission of graduate adviser. Also listed under MN802.*

### ME 718 Thermal Issues in Manufacturing Processes

2/1:0:0:3

Thermal modeling and simulation of manufacturing and materials processing, thermally driven processes, dip coating, thin films, soldering, laser welding and cutting, heat removal from processes generating parasitic heat, thermal management of machining. *Prerequisite ME605 or permission of graduate adviser. Also listed under MN804.*

### ME 803 Combustion 2/1:0:0:3

Chemical characteristics of flames. Heat of formation and of reaction; phase and reaction equilibrium and adiabatic flame temperature; and species concentration in stationary and flowing reacting systems. Chemical kinetics of homogeneous and heterogeneous reacting systems. Branching chain reactions and explosion limits. *Prerequisite: ME 601; ME 706.*

### ME 809 Multiphase Heat Transfer

2/1:0:0:3

Conservation equations for two-phase flow systems with emphasis on gas-liquid mixtures. Bubbly, slug, annular and fog flow regimes. Pressure drops and heat transfer. Nucleate and film boiling; drop-wise and film condensation. Critical heat flux. *Prerequisites: ME 601 & ME 706*

**MECHANICAL ANALYSIS  
AND DESIGN**

**ME 621 Stress Analysis I** 2½:0:0:3  
Review of theory of beam bending. Use of energy methods applied to statically indeterminate structures. Columns, beam columns, beams on elastic foundations. Circular cylindrical shells. Discontinuity analysis in complex structures. *Prerequisite: ME 271 or equivalent.*

**ME 622 Stress Analysis II** 2½:0:0:3  
Stress-strain relationships. Two dimensional stress and strain analysis; equations of compatibility and equilibrium; the Airy stress function. Solutions of various classic two dimensional problems, including those of stress concentration and thermal stress. Torsion of prismatic bars, open and closed thin-walled structures, and multi-cellular structures. *Prerequisite: ME 621.*

**ME 643 Energy Methods in Structural Analysis** 2½:0:0:3  
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: mechanical engineering adviser's approval.*

**ME 644 Mechanical Vibrations I** 2½:0:0:3  
Dynamics of one, two, and multidegree of freedom systems with and without damping. Application to balancing of multicylinder engines, crank mechanism dynamics, and rotating machinery. *Prerequisite: ME 261.*

**ME 645 Mechanical Vibrations II** 2½:0:0:3  
Free and forced longitudinal, torsional and transverse vibrations of bars, shafts, and beams. Lagrange's equations. Rayleigh-Ritz and Dunkerley's approximations. Holzer's and transfer matrix methods. *Prerequisite: ME 644.*

**ME 651 Advanced Dynamics I** 2½:0:0:3  
Kinematics and dynamics of a particle in space: translating and rotating frames of

reference. Systems of particles: plane motion of rigid bodies. Two-body central force problem. Lagrange equations with holonomic and nonholonomic constraints: applications. *Prerequisite: ME 261. Also listed under AE 651.*

**ME 652 Advanced Dynamics II** 2½:0:0:3  
General motions of rigid bodies, Euler's equations, gyroscopic motions and stability, impulsive motions. Linear oscillations of two degree and n-degree of freedom systems, matrix formulations, applications, variational principles. *Prerequisite: ME 647. Also listed under AE 652*

**ME 721-722 Elasticity I, II** each 2½:0:0:3  
Stress and strain tensors; generalized Hooke's Law. Formulation of elasticity problems. Plane stress and strain problems; solutions by complex variables; stress concentrations. Rotating discs and cylinders. Thermal Stresses. Three dimensional problems; St. Venant problems, extension, flexure, torsion. Energy principles and variational methods; approximation techniques. *Prerequisite: ME 622*

**ME 724 Stress Analysis of Composite Materials** 2½:0:0:3  
Composite materials (high strength filaments embedded in a matrix) have relatively large strength to weight ratio as well as other desirable characteristics. Composites are analyzed first from a micromechanics point of view. The relations between the material properties of their components and those of the composite, a material stress concentration factor, and its behavior beyond the elastic range are considered. The stress-strain law of composites, as a function of the directional moduli of elasticity and the directional Poisson's ratios, are presented. It is used in the analysis of various structural components of current interest. *Co-requisite: ME 622.*

**ME 735 Fracture Mechanics** 2½:0:0:3  
Introduction to fracture mechanics. Linear elastic, elastic-plastic and fully plastic fracture mechanics modelling and design. Fatigue and design against fatigue failures. Standard fracture mechanics testing procedures and related material properties. Micromechanics of fracture. Dynamic fracture. Continuum

damage mechanics. *Prerequisite: ME621 or Permission of department adviser. Also listed under CE 645 and MT 645.*

**ME 741 Structural Dynamics** 2½:0:0:3  
Dynamic response of single degree of freedom systems. Theory of vibration of multidegree of freedom systems; influence coefficient method; analytical and numerical solution of dynamic response problems. Nonlinear analysis of single degree of freedom system; emphasis on computer analysis of large complex systems. *Prerequisite: ME 645. Also listed under CE 625.*

**SYSTEMS, CONTROLS, AND ROBOTICS**

**ME 660 Discrete Time Feedback Control** 2½:0:0:3  
Introduction to discrete systems. z-transform. s-to-z transformation. system stability criteria. digital control design via continuous design (root locus technique, frequency domain compensation). discrete design of digital control, sampling rate selection, quantization errors. *Prerequisite: ME 322 or equivalent.*

**ME 661 Sensor Based Robotics** 2½:0:0:3  
Robot mechanisms, robot arm kinematics (direct kinematics, inverse kinematics), Robot arm dynamics (Lagrange-Euler formulation and Hamiltonian formulations), trajectory planning, sensing, end-effector mechanisms, force and moment analysis, introduction to control of robot manipulators. *Prerequisite: ME 660. Also listed under EL522.*

**ME 670 Linear Systems** 2½:0:0:3  
Basic system concepts. Equations describing continuous and discrete-time linear systems. Time domain analysis, state variables, transition matrix, impulse response. Transform methods. Time-variable systems. Controllability, observability and stability. **Also listed under EL 610**

**ME 671 State Space Design For Linear Control Systems** 2½:0:0:3  
Topics to be covered included: canonical forms; control system design objectives; feedback system design by pole placement; linear observers; the separation

principle; linear quadratic optimum control; random processes; Kalman filters as optimum observers; the separation theorem; robust control; the servo compensator problem. *Prerequisite: ME 670. Also listed under EL 725.*

**ME 761 Nonlinear Control** 2½:0:0:3  
Phase-plane analysis of nonlinear systems, describing functions, introduction to Lie algebra, input-output linearization, local and global system decomposition, perturbation control, sliding control. *Prerequisite: ME 660 and ME 671.*

**ME 771 Optimal Control Theory** 2½:0:0:3  
Optimal control problem for deterministic systems with various constraints. Solution for both continuous and discrete-time systems using the maximum principle and dynamics programming. Hamilton-Jacobi theory as applied to the synthesis problem. *Prerequisite: ME 671. Also listed under EL823.*

**ME 860 Application of Nonlinear Control to Robotics** 2½:0:0:3  
Differential geometric approaches for control of nonlinear systems and applications to robot manipulators. Introduction to Lie algebra and Lie bracket. Multi-variable inverses for nonlinear systems, external feedback linearization, zero dynamics. Application of nonlinear control to robotics: inverse dynamics, feed-forward control, PD and PID controllers, variable-structure control, adaptive control techniques (STR and MRAC), and force control. *Prerequisites: ME661 and ME 671. Also listed under EL822.*

**ME 870 H<sup>∞</sup> Frequency Domain Methods in Control** 2½:0:0:3  
Systems and operators, stabilizability, parameterization of stabilizing controllers, H<sup>∞</sup> weighted sensitivity minimization for rational plants, H<sup>2</sup> and H<sup>∞</sup> controller design. *Prerequisite: ME 671. Also listed under EL724.*

**ME 871 Adaptive Control** 2½:0:0:3  
Controllable and observable system models, parameter estimation (least squares, projection algorithm, lattice filters), one and multi-step ahead prediction control, minimum variance, pole placement, LQG control, model reference adaptive control. *Prerequisite: ME 671. Also listed under EL826.*

**ME 872 Stochastic Control** 2½:0:0:3  
Introduction to stochastic control, stochastic processes, covariance and spectral density, stochastic state models, spectral factorization of continuous or discrete time processes, parametric optimization, introduction to prediction and filtering theory. *Prerequisite: ME 771. Also listed under EL827.*

**ME 873 Large Scale Systems and Decentralized Control** 2½:0:0:3  
Introduction to analysis and synthesis of large scale systems. System order reduction algorithms, interconnected system stability, series expansion and singular perturbation. Decentralized control: decentralized fixed modes, LQR, frequency shaped cost functional, and overlapping decompositions. *Prerequisite: ME 771. Also listed under EL825.*

### MANUFACTURING

For the primary listings in this area, refer to the "Manufacturing Engineering" and "Industrial Engineering" sections of the Catalog. Also, refer to ME 615 and ME 616 in the Thermal and Fluids section.

### SELECTED TOPICS, SEMINAR, PROJECTS, THESIS, AND DISSERTATION

**ME 786-787 Special Topics** 2½:0:0:3  
These numbers are reserved for special topics which are offered periodically by the ME Program and are open to first year graduate students. When offered, the specific subject matter is indicated as part of the title after the words "Special Topics:", and the more complete title appears on the student's transcript. *Prerequisites are tailored to the offering.*

**ME 886-887 Advanced Topics** 2½:0:0:3  
These numbers are reserved for advanced topics which are offered periodically by the ME Program and are open to second year and more advanced graduate students. When offered, the specific subject matter is indicated as part of the title after the words "Advanced Topics:", and the more complete title appears on the student's transcript. *Prerequisites are tailored to the offering.*

Offerings in the advanced topics might include kinematic synthesis of mechanisms, thermal stress analysis, nonharmonic and random vibrations, vibrations of space structures, vibrations of plates and shells, and continuum mechanics.

**ME 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 department head.*

**ME 991-992 Seminar in Mechanical Engineering** 0  
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 for Ph.D. students.

**ME 996 M.S. Project** each 3 units  
Engineering project pursued with guidance of faculty member. Project titles submitted in writing to department head and appointed adviser. May be extended to thesis with project adviser's recommendation. Credit only upon completion of project. Re-registration fee: 3-unit charge. *Prerequisite: degree status.*

**ME 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 ME 996, on recommendation of project adviser. Continuous registration required. Maximum of twelve units of ME 996-997 counted toward degree. Re-registration fee: 3-unit charge. *Prerequisite: ME 996.*

**ME 998 Engineer Project** each 3 units  
Analytical, experimental, or design project under guidance of faculty member. Oral examination on project and related topics required of candidates. Continuous registration required until satisfactory project completed. Minimum of six, maximum of twelve units of ME 996-997 counted toward degrees. Re-registration fee: 3-unit charge. *Prerequisite: post-master status.*

## MECHANICAL ENGINEERING

### ME 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. Re-registration fee: 3-unit charge. *Prerequisite: degree status.*

The following graduate courses are offered on an irregular basis in response to student demand:

ME 633	Limit Analysis of Structure
ME 635	Pressure Vessel Analysis
ME 657	Computational Geometry for CAD
ME 658	Computer Aided Design
ME 723	Experimental Stress Analysis
ME 725	Theory of Plates
ME 726	Theory of Shells
ME 733	Applied Plasticity
ME 821	Continuum Mechanics
ME 831	Stability of Structures

## FACULTY

**William R. McShane**, P.E., Professor of Industrial & Systems Engineering; Head, Department of Mechanical and Industrial Engineering; Director, Transportation Training and Research Center. B.E.E., Manhattan College; M.S., Ph.D. (Systems Engineering), Polytechnic Institute of Brooklyn. *Quality control, controls and simulation, engineering economics, laboratory development.*

**Anthony E. Armenakas**, P.E., Professor of Mechanical and Aerospace Engineering. B.S. (CE), Georgia Institute of Technology; M.S. (CE), Illinois Institute of Technology; Ph.D. (Applied Mechanics), Columbia University. *Dynamic analysis of structures, fracture, wave propagation, numerical techniques.*

**Murray Imber**, P.E., Professor of Mechanical Engineering. B.S., University of Illinois; M.S., Columbia University; Eng.Sc.D., Columbia University. *Energy conversion, heat transfer, applied mathematics.*

**Jerome M. Klosner**, P.E., Professor of Mechanical and Aerospace Engineering. B.C.E., The City College of New York; M.S.C.E., (Applied Mechanics) Columbia University; Ph.D., (Applied Mechanics), Polytechnic Institute of Brooklyn. *Structural dynamics, fluid-structure interaction, thermal stress analysis.*

**William P. Vafakos**, P.E., Professor of Mechanical Engineering. B.M.E., Polytechnic Institute of Brooklyn; M.M.E., Polytechnic Institute of Brooklyn; Ph.D., (Applied Mechanics) Polytechnic Institute of Brooklyn; J.D., Brooklyn Law School. *Solid mechanics, structures, vibrations.*

**Richard S. Thorsen**, Vice President, Research and Advanced Programs; Associate Professor of Mechanical Engineering. B.M.E., City College of New York; M.M.E., Ph.D., New York University. *Heat transfer, nuclear reactor safety, solar energy, CAD.*

**Sunil Kumar**, Assistant Professor of Mechanical Engineering. B.Tech (Mechanical Engineering), Indian Institute of Technology; M.A. (Applied Mathematics), State University of New York, Buffalo; M.S. (Mechanical Engineering), State University of New York, Buffalo; Ph.D. (Mechanical Engineering), University of California, Berkeley. *Thermal fluid sciences, applied mathematics.*

**M. Karim Moallemi**, Assistant Professor of Mechanical Engineering. B.S.M.E., Shiraz (Pahlavi University), Shiraz, Iran; M.S.M.E., Purdue University, W. Lafayette, IN; Ph.D., Purdue University, W. Lafayette, IN. *Experimental and computational heat transfer, fluid mechanics, energy conversion, combustion.*

**Anthony P. Tzes**, Assistant professor of Mechanical Engineering. B.S., (E.E), University of Patras, Greece; M.S., (E.E), Ohio State University; Ph.D, Control & Robotics, Ohio State University. *Robotics, adaptive control, computer integrated manufacturing, artificial intelligence, neural networks.*

**George C. Vradis**, Assistant Professor of Mechanical Engineering. B.S. Mechanical Engineering, National Technical University of Athens, Greece; M.S. Mechanical Engineering, Polytechnic University; Ph.D. Mechanical Engineering, Polytechnic University. *Fluid/thermal studies, unsteady flows, energy transfer.*

**Boris A. Bass**, Industry Professor of Mechanical Engineering. Mechanical Engineer, Khabarovsk Polytechnic Institute; Ph.D. in Mechanical Engineering, Moscow Automobile and Highway Institute. *Machine design optimization, computational kinematics and dynamics of mechanisms, stress analysis of mechanical components, engineering drawing, CAD.*

**Charles W. Hoover, Jr.**, Industry Professor of Manufacturing Engineering. B.E. Mechanical Engineering, Yale; B.S. Electronics Engineering, M.I.T.; Ph.D & M.S. Physics, Yale. *Physical Design, manufacturing processes, electronic device assembly.*

**Charles A. Kelly**, Industry Professor of Mechanical and Industrial Engineering. BSEE, University of Detroit; MSEE, Syracuse University. *Work methods, design of manufacturing systems, computer aided engineering, freshman engineering program.*

**Terance E. Kinsky**, Instructor of Mechanical Engineering. B.S.M.E. University of Maryland at College Park. *Engineering graphics, computer aided engineering, manufacturing applications.*

**Raresh Pascali**, Instructor of Mechanical Engineering. B.S., (Aerospace), Polytechnic University; M.S., (Aeronautics & Astronautics), Polytechnic University  
*Computer graphics, CAD/CAM, stress analysis.*

**Spilios Zervos**, Instructor of Mechanical Engineering. Diploma in Mechanical Engineering, University of Patras, Greece; M.S. (Industrial Robotics and Manufacturing Automation), Imperial College, London, England  
*Computer integrated manufacturing, robotics.*

### EMERITUS FACULTY

**Philip Abrami**, Associate Professor Emeritus. B.M.E., M.S., Polytechnic Institute of Brooklyn

**William B. Blesser**, Professor Emeritus. B.M.E., Rensselaer Polytechnic Institute; M.E.E., Polytechnic Institute of Brooklyn

**Martin H. Bloom**, Institute Professor. B.M.E., M.S., Ph.D., Polytechnic Institute of Brooklyn

**Robert Corry**, Associate Professor Emeritus. A.B., Columbia College; B.S., M.S., Ph.D., Columbia University

**John R. Curreri**, Professor Emeritus. B.M.E., M.E.E., Polytechnic Institute of Brooklyn, Adelphi University

**Joseph Kempner**, Professor Emeritus. B.Ae.E., M.E.E., Polytechnic Institute of Brooklyn

**Wheeler K. Mueller, Jr.**, Professor Emeritus. B.S., Iowa State College; M.S., Ph.D., University of Illinois

**Huo-Hsi Pan**, Professor Emeritus. B.S., National Southwest Associated University (China); M.S., Texas A&M; M.S., Kansas State University; Ph.D., University of California (Berkeley)

**Sharad A. Patel**, Professor Emeritus. B.Sc., Benare Hindu University; M.Ae.E., Ph.D., Polytechnic Institute of Brooklyn

**Frank J. Romano**, P.E., Professor Emeritus. B.M.E., Polytechnic Institute of Brooklyn; M.S., Applied Mechanics, Polytechnic Institute of Brooklyn; Ph.D., Applied Mechanics, Polytechnic Institute of Brooklyn

**Bernard W. Shaffer**, P.E., Professor Emeritus. B.M.E., CCNY; M.S., Case Institute of Technology; Ph.D., Brown University

### ADJUNCT FACULTY

**Robert Atkatsch**, Adjunct Lecturer. B.C.E., City College of New York; M.S., Harvard University; Ph.D., Columbia University  
*Numerical analysis, finite elements, plasticity.*

**Bernard Roth**, Adjunct Lecturer. B.M.E., M.S., City College of New York  
*Mechanics, mechanics of materials.*

# OPERATIONS MANAGEMENT

The master's degree program in operations management addresses the productivity needs of manufacturing and service operations. It is a unique 36 unit curriculum that requires the student to view the productivity of the organization from financial, engineering, and production perspectives. The MSOM graduate is equipped with a working knowledge of methods that can enhance his or her decision-making effectiveness in the areas of project planning, resource allocation, inventory management, workforce management, and quality control.

In addition to their prevalence in manufacturing industries, operations managers are found in health care organizations, financial institutions, insurance companies, mass transit systems, hotels, distribution outlets, etc. — often with the title of "vice-president of operations".

This interdisciplinary program is administered by the Department of Management, and is built on Polytechnic's recognized strengths in management, as well as in manufacturing and industrial engineering.

## REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The MSOM curriculum is designed to provide the student with an appreciation for the disciplines that are most pertinent to service and manufacturing operations. The "preliminary courses" are intended for those students who need to enhance their preparation for this master's program. The applicant is expected to have adequate preparation in statistics, accounting, computer usage, and English composition. The "core courses" cover a broad scope of disciplines that are essentially industry neutral, while the "major electives" provide the student with the opportunity to study a selection of subjects in some depth, some of them indus-

try specific. Each grouping of major electives has a distinct orientation, as indicated below. Additionally, there is a required case oriented "advanced topics course" which relates the firm's business strategy to such long-term operations commitments as inventory policy, productive capacity, quality control policy, etc; and, is intended to provide the student with some insights on the top operating officer's contributions to strategic planning.

To be eligible for admission into this program, applicants must hold a baccalaureate degree or its equivalent from an accredited institution. This degree may be in any area except industrial engineering.

### A. Preliminary Courses (0 units towards the degree)

May be waived on the basis of the student's professional experience and/or previous college coursework; otherwise, these courses, or their equivalents, must be taken in addition to the 36 units required for the MSOM.

- MG 502 *Computers in Management*
- MG 504 *Managerial Accounting*
- MA 551 *Applied Statistics (Data Analysis)*
- HU 522 *Seminar in Written English*  
or
- HU 605 *Report Writing*

### B. Core Courses (21 units)\*

- MG 608 *Managerial Economics and the Economic Environment*
- MG 600 *Management Process*  
or
- MG 601 *Organizational Behavior*
- IE 611 *Quality Control and Improvement*
- MG 616 *Job and Workplace Design*
- MG 630 *Operations Management*
- MG 810 *Project Planning and Control*
- MA 868 *Strategic Management of Productivity*

### C. Major Electives (12 units)

A total of four courses must be chosen, with not more than two from each group.

*\*If any of these courses are waived due to previous coursework, then graduate transfer credits and/or substitute graduate courses taken at the Polytechnic can, with the written approval of the MSOM Program Director, be used to fulfill the unit requirements.*

### Quality Management

- IE 612 *Quality Engineering Using Robust Design*
- MG 635 *Introduction to Total Quality Management*

### Manufacturing

- IE 776 *Manufacturing Resource Planning*
- IE 785 *Computer Integrated Manufacturing Systems*

### Human Resources

- MG 612 *Human Resource Management*
- MG 623 *Training in Organizations*  
or
- MG 611 *Career Management*
- MG 627 *Human Resources & Technological Change*

### Management Information Systems

- MG 626 *Human Resource Information Systems*
- MG 650 *Management of the Information Function*
- MG 737 *Analysis & Design of Management Information Systems*

### D. Advanced Topics Course (3 units)

This is a required course which must be taken during the student's last year of studies.

- MG 969 *Operations Strategy*

The total number of units required for the MSOM degree is 36. Each course in the program is 3 units and meets for 2½ hours per week.

## FACULTY

This interdisciplinary program is administered by the Management Department. The faculties of manufacturing engineering, industrial engineering, computer science, social sciences and mathematics participate in delivering this program.

# PHYSICS

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 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 as backgrounds for careers in industry, government and education. 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 a valuable preparation for any science-based or science-connected careers.

Besides the very active fields of solid-state and nuclear physics, other general areas in which physicists are now employed are 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 the 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 some students, this means preparation for graduate school and further study leading to the master's or doctor's degree. For many others, it means professional work in industry, government or in high school teaching. 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 train-

ing 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 the 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 optics, solid-state, x-ray, nuclear physics or quantum theory.

**Instruction in the humanities and social sciences** is built around the 27 credit hours of courses in the humanities and the 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 to discuss their work, review problems or talk physics.

All physics freshmen take a seminar on current advances in physics; seniors may 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 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.

# PHYSICS

## REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE IN PHYSICS

The program requires 128 credits, including 37 credits of required courses in physics. The remaining credits are distributed among required and elective technical, humanities and social sciences courses and free elective courses. (See Typical Course of Study below). The distribution is as follows:

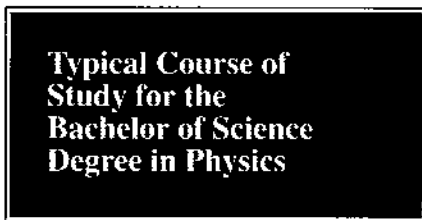
	Credits
<b>Core Courses</b>	
<i>HU 101, 110, 200; SS 104; CS 200; EG 101, CM 101, 102, 111, 112; MA 106, 107, 108, 109 PH 107, 108, 109, 118, 119</i>	48
<b>Physics Required Courses</b>	
<i>PH 113, 210, 234, 302, 311, 312, 323, 324, 335, 336, 390</i>	27
<b>Elective Courses</b>	
<i>Physic/Technical</i>	23
<i>Humanities/Social Science</i>	15
<i>Mathematics</i>	9
<i>Free</i>	6
	128

### Electives

Elective courses are chosen in consultation with the departmental adviser. In Mathematics 9 credits must be taken from the group MA 153, 201, 217, 222, 260 or 358. Recommended Physics elective courses are PH 250, 303, 340, 347, 360, 373 and 374.

### Options

These programs offer the student an opportunity to gain competence in two different and substantial fields of science, to such an extent that upon earning a bachelor's degree he or she may be able to qualify for industrial positions in two distinct areas, or to go on to graduate studies in either of the two subjects. Options in Mathematics, Electronics and Materials Science are described below as examples of these programs.



## FRESHMAN YEAR

### First Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 113	Seminar in Current Physics	2	0	2
CM 101	General Chemistry I	3	0	2.5
CM 111	General Chemistry Lab I	0	1.5	0.5
MA 106	Calculus I	5	0	4
EG 101	Introduction to Engineering	2	3	3
HU 101	Writing and the Humanities I	3	0	3
SL 101	Freshman Seminar	1	1	0
PE 10x	Physical Education	0	2	0
				15

### Second Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
CS 200	Intro. Prog. Meth.	3	0	3
CM 102	General Chemistry II	2.5	0	2.5
CM 112	General Chemistry Lab. II	0	1.5	0.5
MA 107	Calculus II	4	0	4
PH 107	Mechanics	3	0	3
SS 104	Contemp. World History or			
HU 200	Writing and the Humanities II	3	0	3
PE 10x	Physical Education	0	2	0
				16

## SOPHOMORE YEAR

### First Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
MA 108	Diff. Eqs. and Num. Methods	3	0	3
MA 109	Multidimensional Calculus	4	0	3
PH 108	Elec., Mag. & Fluids	4	0	3
PH 118	Laboratory for PH 108	0	1.5	0.5
PH 210	Analytical Mechanics	3	0	3
SS 104	Contemp. World History or			
HU 200	Writing and the Humanities II	3	0	3
PE 10x	Physical Education	0	2	0
				15.5

### Second Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 109	Waves, Optics & Thermo.	4	0	3
PH 119	Laboratory for PH 109	0	1.5	0.5
PH 234	Intro. to Modern Physics	2	0	2
PH 250	Electronics for Phys. Scient.	3	3	4
HU 110	Professional Report Writing	3	0	3
PE 10x	Physical Education	0	2	0
	Math. Elective	3	0	3
				15.5

## JUNIOR YEAR

### First Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 311	Thermodynamics <sup>1</sup>	3	0	3
PH 323	Electricity and Magnetism I <sup>2</sup>	2	0	2
PH 302	Advanced Lab. I	1	3	2
PH 335	Quantum Physics <sup>3</sup>	3	0	3
	Math Elective <sup>4</sup>	3	0	3
	HU/SS Elective <sup>5</sup>	3	0	3
				16

### Second Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 312	Stat. Phys. & Kinetic Theory	3	0	3
PH 324	Electricity and Magnetism II <sup>2</sup>	2	0	2
PH 303	Advanced Lab. II <sup>2</sup>	1	3	2
PH 336	Quantum Mechanics <sup>3</sup>	3	0	3
	Math. Elective <sup>4</sup>	3	0	3
	HU/SS Elective <sup>5</sup>	3	0	3
				16

## SENIOR YEAR

### First Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 373	Intro. Theo. Phys I <sup>1</sup>	3	0	3
PH 347	Modern Optics <sup>2</sup>	3	3	4
PH 667	Quantum Mechanics I <sup>3</sup>	3	0	3
	HU/SS Elective <sup>4</sup>	3	0	3
	Free Elective	3	0	3
				16

### Second Semester

No.	Subject	Hours/Week		
		Cl.	Lab.	Cr.
PH 340	Computer Methods in Physics <sup>1</sup>	3	3	4
PH 374	Intro. Theo. Phys II <sup>1</sup>	3	0	3
PH 390	Senior Seminar	2	0	2
	HU/SS Electives <sup>4</sup>	6	0	6
	Free Elective	3	0	3
				18

<sup>1</sup> Consult the general Degree Requirements section of this catalog for University Regulations.

<sup>2</sup> Although not required, Physical Education is strongly recommended.

<sup>3</sup> Electives are chosen with the adviser's approval.

<sup>4</sup> The following course substitutions are permitted with the approval of the undergraduate adviser: ME 201 for PH 311, EE 370 & 374 for PH 250, PH 523 or EE 163 for PH 323, PH 524 or EE 164 for PH 324, PH 535 for PH 335, PH 536 for PH 336, PH 547 & 548 for PH 347.

<sup>5</sup> Mathematics, Elective courses (9 credits) are to be chosen from MA 153, 201, 217, 222, 260 and 358.

<sup>6</sup> Humanities and Social Sciences. Required courses (12 credits) are HU 101, 110, 200 and SS 104. Elective courses (15 credits); students are strongly urged to select two or three courses from an area of concentration described in the general Degree Requirements.

<sup>7</sup> Advanced electives are strongly recommended for students intending to pursue graduate studies in physics.

The option in Mathematics provides strong training in both Physics and Mathematics, approaching the requirements for separate degrees in each subject. The options in Electronics and Materials may be viewed as similar to Applied Physics programs with concentrations in the respective areas. In all cases the student benefits from the strong basic training in Physics and positions himself for further training or direct employment in the area of his option.

Electronics and Materials Sciences are areas of immense importance in today's technology, providing a wide range of employment opportunities in addition to those available in Physics. As examples, in the active technology areas of Microelectronics and High Temperature Superconductivity, combined knowledge of Physics and Electronics or Materials opens many opportunities for employment. A student with a strong basic training in Physics, in addition to that in his or her option, may enjoy in his career more flexibility and greater ability to adjust to changing requirements in technology. The changes in course requirements for each option from that of the B.S. in Physics are listed below.

**MATHEMATICS OPTION**

Replace 9 credits of Math electives and 9 credits of Physics electives with the following set of math electives:

- MA 153 (3:0:3) Elements of Linear Algebra
  - MA 201 (3:0:3) Applied Analysis I
  - MA 202 (3:0:3) Applied Analysis II
  - MA 223 (3:0:3) Introduction to Probability
  - MA 260 (3:0:3) Vector Analysis and Partial Differential Equations
  - MA 358 (3:0:3) Introductory Numerical Analysis
- 18 credits**

**ELECTRONICS OPTION**

Replace 19 credits of Physics electives with the following set of electronics electives:

- EE 101 (3:0:3) Electric Circuits I
- EE 102 (3:0:3) Electric Circuits II
- EE 109 (4:0:4) Solid State Devices and Circuits I
- EE 110(3:0:3) Solid State Devices and Circuits II
- EE 105 (3:0:3) Signals, Systems, and Transforms

- EE 192 (0.5:1.5:1) Sophomore EE laboratory
  - EE 195 (1:3:2) Junior EE laboratory
- 19 credits**

**MATERIALS OPTION**

Replace 12 credits of Physics electives with 12 credits in Materials Science:

- MT 305 (3:0:3) Mechanical Properties of Materials
- MT 306 (2:3:3) Nature and Properties of Structural Materials
- MT 340 (3:0:3) Manufacturing Processes
- MT 375 (3:0:3) Semiconductor Technology
- MT 603/4(4.5:2:6) Introduction to Electron Microscopy I,II

or appropriate alternatives.

**12 credits**



The Department of Physics offers graduate programs leading to the degrees of master of science and doctor of philosophy in 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, is equipped for all types of crystal analysis and has unique capabilities in high resolution x-ray interferometry. Surface physics and materials physics studies are performed both in the department's extensive surface science laboratories and at various synchrotron x-ray 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.

**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 Requirement)

The minimum course requirements for the master's degree are as follows:

No.	Subject	Units
PH 667	Quantum Mechanics I	3
PH 953-954	Graduate Seminar I,II	3
PH 901-902	Physics Colloquium I,II	0
	Elective Courses	30
	Total	36

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

## PHYSICS

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:

No.	Subject	Units
PH 669-670	Quantum Mechanics III,IV	6
PH 953-954	Graduate Seminar I,II	3
PH 901-902	Physics Colloquium I,II	0
PH 999	Research in Physics	24
	Additional Physics courses	33
	Minor Courses	12
	Elective Courses Or	
	Additional Research in Physics	12
	Total	90

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.

### UNDERGRADUATE COURSES

#### PH 107 Mechanics 4:0:3

An introduction to the motion of particles and objects. One dimensional motion. Forces and acceleration. The conservation of energy and momentum. Vectors and two-dimensional motion. Rotation. The free and driven harmonic oscillator. *Prerequisites: MA 106 or a grade of C+ or better in MA 105.*

#### PH 108 Electricity, Magnetism, and Fluids 4:0:3

An introduction to electric and magnetic forces and fields. Electric charge density. Electric fields from spherical and planar charge distributions. Electric potential. Capacitance. Magnetic forces. Magnetic field from a current loop. Inductance. Ferromagnetism. Current, flow, resistance, and introduction to band theory of solids. Fluids at rest and in motion. *Prerequisites: MA 106 and PH 107. Corequisite: PH 118*

#### PH 109 Waves, Optics, and Thermodynamics 4:0:3

Water, sound, and radio waves. Reflection, scattering, and absorption. Standing waves and spectra. Superposition: diffraction and beats. Geometrical optics. Applications of temperature, heat, and entropy. *Prerequisites: PH 108 and MA 107. Corequisites: PH 119, and preferably MA 108 or MA 109.*

#### PH 113 Seminar in Current Physics 2:0:2

Analyses, 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.

#### PH 118 Physics Laboratory for PH 108 0:1½:½

Principles of measurement in electric, magnetic, and thermodynamic experiments. Lab fee required. *Prerequisite: PH 107. Corequisite: Students who register for PH 118 must coregister for PH 108 unless excused in writing by the Director of the Introductory Physics Program; if they withdraw from one, they must withdraw from the other.*

#### PH 119 Physics Laboratory for PH 109 0:1½:½

Continuation of PH 118. Experiments in optics and sound. Lab fee required. *Prerequisite: PH 108 and PH 118. Corequisite: Students who register for PH 119 must register for PH 109 unless excused in writing by the Director of the Introductory Physics Program; if they withdraw from one, they must also withdraw from the other.*

#### PH 210 Analytical Mechanics 3:0:3

Statics by virtual work and potential energy methods. Stability of equilibrium. Particle dynamics, harmonic oscillator and planetary motion. Plane rigid body dynamics. *Prerequisite: PH 104. Corequisite: MA 108.*

#### PH 234 Introduction to Modern Physics 2:0:2

Relativity; quantization of electricity, light, and energy; the nuclear atom and electron spin; electron waves; the Schroedinger equation; some properties of solids; atomic physics; nuclear physics and elementary particles. Lectures and discussion sessions. *Prerequisites: PH 108 and PH 118. Corequisite: PH 109 and PH 119; if students withdraw from PH 119 while coregistered in PH 234, they must also withdraw from PH 234.*

#### 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 measurements 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. *Corequisite: PH 109 and MA 108.*

#### 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. *Corequisite: PH 109.*

**PH 302-303 Advanced Lab I,II\***

*each 1:3:2*

Precision measurements in mechanics, heat, electricity, optics, modern physics. Lab fee required. Given alternate years. *PH 302 colprerequisite: PH 335. PH 303 colprerequisite: PH 302, 336.*

**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 thermodynamics relations. *Prerequisite: PH 234.*

**PH 312 Statistical Physics and Kinetic Theory**

*3:0:3*

Introduction to the theory and applications of statistical physics. Entropy, probability distributions, and equations of state. Elementary kinetic theory of gases including transport properties. Phase space and density of states. Applications to specific heats, blackbody radiation, physical, and optical properties. Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distributions. *Prerequisite: PH 311 or ME 201 or consent of instructor.*

**PH 323-324 Electricity and Magnetism I,II\***

*each 2:0:2*

Properties of the electrostatic, magnetostatic and electromagnetic field in vacuum and in material media. Maxwell's equations with applications to elementary problems. *Corequisite: MA 109.*

**PH 335 Quantum Physics**

*3:0:3*

Electrons 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 234.*

**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 200.*

**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 and 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 109 and PH 234.*

**PH 372 X-ray Diffraction\***

*2:3:3*

Production and properties of x-rays. Elements of crystallography. Stereographic projections. Powder and single crystal diffraction techniques. Structures and crystal orientations. Stress analyses and phase and quantitative chemical analysis by x-ray techniques. *Prerequisite: MA 109 and PH 109.*

*Also listed under MT 412.*

**PH 373-374 Introduction to Theoretical Physics I,II\***

*each 3:0:3*

Mathematical methods used in classical theoretical physics. Lagrange's equations, vibrating strings and membranes, flow of fluids, flow of heat, electrostatics, electrodynamics, Maxwell's equations. *PH 373 prerequisites: PH 210 and PH 324. PH 374 prerequisite: PH 373.*

**PH 381-382 Reading Course in Physics I,II**

*each 2:0:2*

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. *Corequisite: PH 336*

**PH 391-394 Bachelor's Thesis in Physics**

*each 2:0:2*

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.

\* Not offered every year.

**GRADUATE COURSES**

**PH 523-524† Electricity and Magnetism I, II\***

*each 2:0:2*

Electrostatics boundary-value solutions to Poisson's and Laplace's equations in conductors and dielectrics, multipole expansions, electrostatic potential energy, method of images, magnetostatics, Ampere's law, time varying fields, Maxwell's equations and conservation laws, plane electromagnetic waves, radiation systems and diffraction, special theory of relativity, and covariance of electrodynamics, radiation by moving charges, electromagnetic interactions with matter. *Prerequisites: PH 234 and PH 109 or equivalents.*

**PH 535-536† Quantum Physics I, II\***

*each 3:0:3*

Relativity, quantum statistics, Schrodinger wave equation and solutions, time dependent and time independent perturbation theory, multi-electron spectra, RS and jj coupling, collision theory, molecular spectra, wave mechanics of solids, nuclear models, and alpha, beta, and gamma decay, fission, fusion, elementary particles, quarks and leptons. *Prerequisite: PH 234 or equivalent.*

**PH 547† Modern Optics**

*3:0:3*

The physics of optics using both classical and semiclassical descriptions. The classical and quantum interactions of light with matter. Diffraction of waves and wave packets by obstacles. Fourier transform optics, holography, Fourier transform spectroscopy. Coherence and quantum aspects of light. Geometrical optics. Matrix optics. Crystal

## PHYSICS

optics. Introduction to electro-optics and nonlinear optics. *Prerequisites:* PH 324, PH 336 or equivalents.

**PH 548<sup>+</sup> Modern Optics Lab** 0:3:1  
The modern optics laboratory includes experimental investigations into laser modes, velocity of light by time-of-flight, Fourier optics, holography, Fourier transform spectroscopy, crystal optics, and nonlinear optics. *Prerequisite or corequisite:* PH 547 or equivalent.

**PH 603<sup>+</sup> Graduate Laboratory\*** 0:4:3  
Practice in experimental research techniques through setting up and carrying out experimental projects in classical and modern physics. Lab fee required.

**PH 604<sup>+</sup> 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.

**PH 605-606<sup>+</sup> 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 in 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\*** 2½:0:3  
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.

**PH 608 Mathematical Methods of Physics II\*** 2½:0:3  
N-dimensional vector spaces and Hilbert space. Calculus of variations and eigenvalue problems. Green's function solutions to differential equations. Integral equations. Unifying roles of mathematics in physics and physical concepts and problems. *Pre-*

*requisite:* PH 607 or consent of instructor.  
**PH 615 Theoretical Mechanics I**

2½:0:3  
Principles of particle and rigid body dynamics. Lagrange's equations. Small vibrations of coupled systems, normal modes of oscillation.

**PH 616 Theoretical Mechanics II** 2½:0:3  
Hamiltonian mechanics. Transformation theories of mechanics including the Hamilton-Jacobi and Poisson bracket formulation, Lagrangian formulation of mechanics of continuous media. *Prerequisite:* PH 615.

**PH 624 Electromagnetic Theory I** 2½:0:3

Maxwell's equations. Plane waves. Relativistic covariance of electromagnetic field. Motions of charges in fields. Fields of moving charges. Hertz and Lienard-Wiechert potentials. Radiation from charges, dipoles and quadrupoles.

**PH 625 Electromagnetic Theory II** 2.5:0:3

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 ferrites; waves in inhomogeneous media. *Prerequisite:* PH 624.  
Also listed under EL 673

**PH 633-634<sup>+</sup> Introduction to Nuclear and Elementary Particles Physics I,II\*** each 2½:0:3

Fundamental properties of atomic nucleus and its constituents. Two-body problems at low energies and the theory of nuclear forces. Nuclear radioactivities such as alpha-, gamma-, and beta-decay. General features of nuclear reactions and of the various nuclear models. Basic properties of elementary particles, their modes of decay, interactions, classifications and invariance laws. PH 663 *prerequisite:* PH 336 or equivalent. PH 634 *prerequisite:* PH 633.

**PH 635 Biophysics I\*** 2½:0:3  
Physical properties of biological systems. Natural properties of biological components. Structural strength, elasticity of bones, muscle, other tissue. Flow properties through tissue, diffusion of gases and liquids, flow through vessels. Compart-

mental analysis, models, trace analysis. Effects of stimuli on various body organs and mechanisms. Temperature effects, electrical excitations. *Prerequisite:* PH 335 or equivalent.

**PH 636 Biophysics II\*** 2½:0:3  
Transport processes in 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.

**PH 637 Radiation Physics with Biological and Medical Applications\*** 2½:0:3

Principles of atomic and molecular physics with stress on the problems of radiation and biological effects of 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.

**PH 638<sup>+</sup> Quantum Mechanics with Applications\*** 2½:0:3

Wave mechanics with applications to atomic and nuclear systems. Use of Schroedinger wave equation with perturbation theory for eigenvalue/eigenfunctions of harmonic oscillator and collision and applications to atomic nuclei. This course can be used by medical physics students to satisfy the requirement of PH 667 for a master's degree in physics. *Prerequisite:* PH 335 and PH 336 or equivalents.

**PH 651-652<sup>+</sup> Introduction to Solid-State Physics I,II** each 2½:0:3  
Phenomena and theory of physics of crystalline solids. Topics from thermal, magnetic, electrical and optical properties of metals, insulators and semiconductors. PH 651 *prerequisite:* PH 336 or equivalent. PH 652 *prerequisite:* PH 651.

**PH 663 Statistical Mechanics I** 2½:0:3  
Equilibrium distributions. Relationships to laws of thermodynamics. Quantum effects. Maxwell-Boltzmann, Fermi-Dirac, Bose-Einstein distributions. Applications to bulk properties of phenomena using Boltzmann transport equation.  
Also listed under EL 651

**PH 664 Statistical Mechanics II** 2½:0:3

Micro-, macro-, and grand-canonical ensembles and principles of classical statistical mechanics. Condensation phenomena. Treatment of fluctuation and transport phenomena. Density matrix formalism of quantum statistical mechanics. Many-body problems. *Prerequisites: PH 663 and PH 667, or equivalents. Also listed under EL 652*

**PH 667-668† Quantum Mechanics I,II**

*each 2½:0:3*

Quantum mechanics with applications to atomic systems. The use of Schroedinger's equations. Angular momentum and spin. Problems and approximation methods. Semiclassical theory of field-matter interaction.

*Also listed under EL 655-656*

**PH 669-670 Quantum Mechanics**

**III,IV** *each 2½:0:3*

Theory of measurement and connection with classical dynamics. The Dirac formulation, transformation theory, scattering theory and introduction to the theory of radiation. *PH 669 prerequisites: PH 616, PH 624 and PH 667-668. PH 670 prerequisite: PH 669.*

**PH 671-672† X-ray Diffraction I,II\***

*each 2½:0:3*

Theory of x-ray scattering, crystallography and crystal optics, diffraction by crystalline materials, space group theory, theory of x-ray diffraction methods, including Laue techniques, rotating crystal and moving film methods, single crystal diffractometry. Introduction to powder methods. Interpretations of x-ray powder data. Theories and methods of crystal structure analysis, crystallite size determination, scattering by amorphous substances, crystal perfection, small angle scattering. *PH 672 prerequisite: PH 671 or consent of instructor.*

**PH 751-752 Theory of Solids I,II\***

*each 2½:0:3*

Quantum and statistical mechanics of the band theory of solids as applied to electrical, thermal and optical properties of metals, semiconductors and insulators. *PH 751 prerequisites: PH 664 and PH 668. PH 752 prerequisite: PH 751.*

**PH 753-754 Crystal Dynamics I,II\***

*each 2½:0:3*

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 solid state theory and principles of crystal symmetry. *PH 753 prerequisites: PH 616 and PH 624. PH 754 prerequisites: PH 668 and PH 753.*

**PH 761-762 Relativistic Quantum Mechanics and Field Theory I,II\***

*each 2½:0:3*

Dirac theory of the electron and positron, application of Dirac equation for discussion of electron spin and fine structure of hydrogen atom spectrum. Scattering of relativistic particles. Brief review of Lagrangian formalism of classical fields. Quantization of fields, scattering and the S-matrix theory. Feynman diagrams and renormalization theory. Applications of dispersion relations to strong interactions. *PH 761 prerequisite: PH 670. PH 762 prerequisite: PH 761.*

**PH 763-764 Nuclear Theory I,II\***

*each 2½:0:3*

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\***

*each 2½:0:3*

Basic properties of particles, their interactions and invariance laws of particle physics. Fundamental properties and quantum numbers of the elementary particles, classification of interactions, invariance under space reflections, time reversal, charge conjugation, isotopic spin. Calculation of cross-sections, branching ratios, lifetimes. Higher symmetry schemes of SU(3), SU(6), etc. Field theory and second quantization. *PH 765 prerequisite: PH 670. PH 766 prerequisite: PH 765.*

**PH 780 Special and General Theory of Relativity\***

*2½:0:3*

Einstein's theory of relativity, Minkowski geometry, relativistic mechanics and electrodynamics, applications of theory with special reference to high-energy physics; gravitation 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 ponderomotive equations. *Prerequisites: PH 616 and PH 624 or equivalents.*

**PH 801-802 Selected Topics in**

**Advanced Physics I,II\*** *each 2½:0:3*

Current or advanced topics of particular interest to graduate students. Subject matter determined each year by students and faculty. May be given in more than one section. Consult department office for current offerings.

**PH 901-902 Physics Colloquium I,II**

*each 2:0:0*

Topical subjects of experimental and theoretical physics by the staff and outside lectures. Fee required. Required of all master's and doctoral candidates.

**PH 953-954 Graduate Seminar I,II**

*each 1½ units*

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**

*each 2½:0:3*

Selected papers and current literature in a specialized field of physics guided by a faculty member. *Prerequisite: graduate adviser's and supervising faculty member's consent.*

**PH 999 Research in Physics**

*each 3 units*

An original investigation in some branch of physics or chemical physics, which may serve as basis for the degree of master of science or doctor of philosophy, to be performed under the direction of a member of the department. The number of research credits registered for each semester should reflect realistically the time devoted to research. *Prerequisites: degree status and graduate adviser's and research director's consent.*

\* Not offered every year.

† May be taken for either undergraduate or graduate credit.

**FACULTY**

**Edward L. Wolf**, Professor of Physics and Head of Department  
B.A., Swarthmore College; Ph.D., Cornell University  
*Experimental condensed matter physics, superconductivity, scanning tunneling microscopy, and electron tunneling spectroscopy.*

**Stephen Arnold**, Thomas Potts Professor of Physics  
B.S., University of Toledo; M.A., Ph.D., City University of New York.  
*Organic solid-state and microparticle photo-physics*

**Patrick T. Cahill**, Professor of Physics  
B.S., M.S., University of New Hampshire; Ph.D., Harvard University  
*Medical physics, magnetic resonance imaging, atomic physics*

**Deo C. Choudhury**, Professor of Physics  
B.S., M.Sc., University of Calcutta; 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, theory of x-ray diffraction*

**Erich E. Kunhardt**, Professor of Electrophysics (Electrical Engineering), Professor of Physics  
B.S., M.S., New York University; Ph.D., Polytechnic Institute of New York  
*Plasma Physics, Non-equilibrium properties*

**K. Ming Leung**, Professor of Physics  
B.S., University of Missouri; Ph.D., University of Wisconsin  
*Theoretical condensed matter*

**Peter S. Riseborough**, Professor of Physics  
B.S., Ph.D., Imperial College, London  
*Theoretical condensed matter physics*

**Donald B. Scarf**, Professor of Physics  
B.A., Lehigh University; Ph.D., Princeton University  
*Quantum optics; atomic physics*

**Lorcan M. Folan**, Associate Professor of Physics  
B.Sc., Trinity College, Dublin; Ph.D., Polytechnic University  
*Energy transfer in condensed matter, aerosols*

**Tito Huber**, Associate Professor of Physics  
B.A., Balseiro Physics Institute, Bariloche, Argentina; Ph. D. Brown  
*Experimental condensed matter physics*

**Sarath C. Meepagala**, Assistant Professor of Physics  
B.Sc., University of Colombo; M.S., Ph.D., Wayne State University.  
*Scanning Tunneling Microscopy, Superconducting Devices*

**Carol Thompson**, Assistant Professor of Physics  
B.S., California Institute of Technology; Ph.D., University of Houston  
*Experimental Materials Physics, X-ray Scattering*

**ADJUNCT FACULTY**

**Benjamin Bloch**, Adjunct Professor of Physics  
B.A., Columbia University; Ph.D., Polytechnic Institute of Brooklyn

**Carl Henry Leyh**, Adjunct Associate Professor of Physics  
B.S., Drexel University; M.S., Ph.D., University of Virginia  
*Experimental Physics, Gravitation*

**Jack A. Lowenthal**, Adjunct Professor of Physics  
B.S., Polytechnic Institute of New York; M.S., Ph.D., Pennsylvania State University  
*Electro-optics; teaching of physics.*

**Melvin Pomerantz**, Adjunct Professor of Physics  
B. S. Polytechnic Institute of New York; M. S., Ph.D., Univ. California, Berkeley  
*Condensed Matter Physics, Electronic devices*

**Faige Singer Spolter**, Adjunct Assistant Professor of Physics  
B. S., Barnard College; M. A., M. Phil., Ph.D. Columbia University  
*Theoretical quantum optics*

**EMERITUS AND ASSOCIATED FAC-**

**John J. Dropkin**, Professor Emeritus  
B.A., Columbia University; M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Solid-state physics*

**Terje Kjeldaas, Jr.**, Professor Emeritus  
B.S., Polytechnic Institute of Brooklyn; M.A., Columbia University; Ph.D., University of Pittsburgh  
*Theoretical solid state and atomic 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*

**H. William Schleuning**, Professor Emeritus  
M.A., New York University  
*Vacuum and thin films*

**Hilda Bass**, Emeritus Associate Professor of Physics  
B.A., Hunter College; M.A., Smith College  
*Atomic and nuclear physics; physics education*

**Walter Kiszzenick**, Emeritus Associate Professor of Physics  
B.S. Brooklyn College; M.S., Ph.D., Polytechnic Institute of Brooklyn  
*Experimental Physics, X-ray Scattering, Teaching Physics.*

**Raphael Aronson**, Professor of Physics  
B.S., University of Minnesota; M.A., Ph.D., Harvard University  
*Transport Theory*

**Meir Menes**, Associate Professor of Physics  
B.S., Cooper Union; Ph.D., New York University  
*Experimental solid-state physics; gaseous electronics*

**Nathan Wainfan**, Professor of Physics  
B.E.E., M.S., New York University, Ph.D., University of Southern California  
*X-ray Physics; gas discharges*

<b>RESEARCH FACULTY</b>
-------------------------

**N. D. Alexandropoulos**, Research Professor  
 Dipl. in Physics, Doctor of Science,  
 National University of Greece, Athens  
*Solid state physics, x-ray diffraction*

**Walter Egan**, Research Professor of  
 Physics  
 B.E.E., City College; M.A., Columbia  
 University; Ph.D. Polytechnic Institute of  
 Brooklyn.  
*Polarimetry, Remote Sensing, Optical  
 Properties*

**Peter Hanggi**, Research Professor of  
 Physics  
 B.S., College of Mathematics and  
 Natural Sciences, Basel; M.S., Ph.D.,  
 University of Basel  
*Statistical mechanics, quantum tunneling*

**Yuli M. Ivanchenko**, Research  
 Professor of Physics  
 M.S., University of Kharkov; Ph.D.,  
 University of Donetsk  
*Condensed Matter Theory,  
 Superconductivity, Tunneling*

**Oleg A. Mezrin**, Research Professor of  
 Physics  
 B. S. Tachkent, M. S., Ph.D., A. F. Ioffe  
 Physical-Techn. Inst., Leningrad  
*Physics of semiconductors, theory of  
 high speed electron devices*

# 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.

## ADMISSION TO 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 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:

No.	Course	Units
CH 921	<i>Polymer Processing</i>	3
CH 922	<i>Polymer Engineering Laboratory</i>	3
CH 926	<i>Engineering Properties of Polymers</i>	3
CM 771	<i>Introductory Polymer Chemistry</i>	3
CM 783	<i>Laboratory Methods in Polymer Chemistry</i>	3
CH 991-2	<i>Seminar</i>	0

### Guided Study/Thesis Option

Either		
CH 930	<i>Guided Studies in Polymer Science and Engineering</i>	6
<i>Electives</i>		15
or		
CH 997	<i>Thesis for Degree of Master of Science in Polymer Science and Engineering</i>	12
<i>Electives</i>		9
<i>As electives, any graduate courses in Chemistry and Chemical Engineering may be chosen. The approval of the graduate adviser will be needed in order to take courses in other disciplines.</i>		
<i>Total</i>		36

To meet graduate requirements, students must have an overall B average in all courses and must not obtain more than two grades of C in required subjects.

## REQUIREMENTS FOR THE DEGREE 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 dean of research and graduate studies 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.

Each candidate for the doctorate must complete a minimum of 90 units of academic work beyond the Bachelor's Degree, including a minimum of 48 units of dissertation research. Although the student may elect to take more than 48 units of Ph.D. thesis, only 48 units of Ph.D. thesis can be counted in the required 90 unit minimum, and these must be taken at Polytechnic. A minimum of 24 graduate units beyond the Bachelor's degree (not including Ph.D. or M.S. Thesis units) are required in Polymer Science and Engineering subjects, of which at least 9 must be taken at the Polytechnic in the required subjects. A minor is required within a science or engineering department and must consist of at least 9 units taken at the Polytechnic. The minor must meet the approval of the graduate adviser in polymer science and engineering.

Once the student has started the dissertation, registration must be continuous (excluding summer sessions) until it is completed and accepted.

Attendance is required at Chemical Engineering Seminars for at least four semesters. To meet graduation requirements, students must have an overall B average in all courses, excluding Thesis, and must not obtain more than three grades of C in required subjects.

Candidates for the degree of Doctor of Philosophy in Polymer Science and Engineering are to plan their programs in accordance with the following requirements:

No.	Course	Units
CH 921	<i>Polymer Processing</i>	3
CH 922	<i>Polymer Engineering Laboratory</i>	3
CH 926	<i>Engineering Properties of Polymers</i>	3
CH 771	<i>Introductory Polymer Chemistry</i>	3
CH 781	<i>Solution Properties of High Polymers</i>	3
CH 782	<i>Macromolecules in the Solid State</i>	3
CH 783	<i>Laboratory Methods in Polymer Chemistry</i>	3
CH 772	<i>Synthesis of High Polymers</i>	3
CH 991-92	<i>Seminar in Chemical Engineering</i>	0
Electives:	<i>3 courses</i>	9

Any graduate courses in Chemistry and Chemical Engineering may be chosen. The approval of the graduate adviser will be needed in order to take courses in other disciplines.

Minor: 3 courses 9

A minor must be taken in another science or engineering department with the approval of the graduate adviser in Polymer Science and Engineering.

CH 989 *Dissertation for Degree of Doctor of Philosophy in Polymer Science and Engineering* 48

Up to twelve units of Master's Thesis can be included here.

Total 90

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** 2½:0:0:3

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. *Prerequisites: CH 631, MA 531 and MA 532 or equivalent.*

CH 917 **Introduction to Polymeric Materials** 2½:0:0:3

Principles of technological aspects of polymerization, compounding and processing of polymeric materials, their properties and applications. Thermoplastic materials such as polyethylene, polypropylene, poly(vinyl chloride), polystyrene, acrylics and engineering plastics are discussed. Thermosetting materials covered include phenolics, epoxies, unsaturated polyesters, amino-plastics, polyurethanes and silicones. *Prerequisite: CM 123 or equivalent.*

CH 921 **Polymer Processing** 2½:0:0:3

Applications of engineering principles to 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. *Prerequisite: CH 220 and CH 221 or instructor's permission.*

CH 922 **Polymer Engineering Laboratory** 0:4:0:3

Engineering principles involved in polymer processing and analysis of their properties. Experiments include general processing methods, such as injection molding, extrusion, and compression molding. Properties are evaluated by measurements at small deformations, such as stress relaxation and dynamic mechanical analysis, as well as the ultimate or fracture tests. *Prerequisite: CH 921 and CH 926.*

CH 924 **Polymerization Reaction Engineering** 2½:0:0:3

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 781 or equivalent.*

CH 926 **Engineering Properties of Polymers** 2½:0:0:3

Mechanical properties and structures of solid polymers. Viscoelastic theory and response of amorphous, crystalline and composite materials in stress-strain, creep, stress relaxation and dynamic tests. Effects of orientation and previous history on mechanical behavior. *Prerequisites: CH 917, CM 771.*

CH 928 **Polymer Composites** 2½:0:0:3

Production, properties and durability of polymer composites, with emphasis on continuous fiber-reinforced polymer matrices. Modelling of processing. Chemical compositions, cure kinetics and rheology, crystallization, viscoelasticity, processing methods, residual stresses and fracture mechanics. Composites in service. *Prerequisites: CH 921 and CH 926.*

CH 933 **Coatings Technology** 2½:0:0:3

Chemistry, manufacture and applications of organic film formers; solvents and solubility principles; mechanisms and methods of film application, formation, conversion. Chemistry, manufacture and applications of pigments. Principles and methods of pigment dispersion and coatings preparation, including influence of rheology and surface chemistry. Principles of formulation of important paints and clear coatings. Specifications and test methods for coatings. *Prerequisite: CM123 or equivalent.*

CH 940-941 **Selected Topics in Polymer Science and Engineering, I, II** each 2½:0:0:3

Topics of special interest in polymer science and engineering are announced in advance of each semester offering. *Prerequisite: adviser's approval.*

CM 771 **Introductory Polymer Chemistry** 2½:0:0:3

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 crys-

## POLYMER SCIENCE AND ENGINEERING

tallization, spectroscopic techniques for polymer study, properties of commercial polymers. *Prerequisites:* CM 123, CM 125 and CM 162.

### CM 772 Syntheses of High Polymers 2½:0:0.3

Organic aspects. Chemistry of monomer and polymer formation. 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 2½:0:0.3

Application 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, and CM 771 or CM 783.

### CM 782 Macromolecules in the Solid State 2½:0:0.3

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 0:5:0.3

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 2½:0:0.3

Presentation at intervals of various advanced or specialized topics in polymer chemistry.

## PROJECTS, THESES AND SEMINARS

### CH 930 Guided Studies in Polymer Science and Engineering 6 units, each 2 units

Presentations of a comprehensive report of some problem 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 report to advisers one week before last day of classes. *Prerequisite:* degree status.

### CH 987 Thesis for Degree of Master of Science in Polymer Science and Engineering 12 units, each 3 units

Thesis for master's degree in polymer science and engineering should give results of original investigations of problem 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 before or on seventh Wednesday prior to commencement. *Prerequisite:* degree status.

### CH 989 Dissertation for Degree of Doctor of Philosophy in Polymer Science and Engineering 48 units, each 3 units

Dissertation must give results of independent investigations of problem 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 doctoral 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 0:2½:0:0

Recent developments in the field of chemical engineering or polymer science and engineering will be presented through lectures given by experts 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

**Mark M. Green**, Professor of Chemistry

**T.K. Kwei**, Professor of Polymer Chemistry

**Yoshiyuki Okamoto**, Professor of Chemistry

**Eli M. Pearce**, University Professor  
Director, Polymer Research Institute

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

**Guiliana Tesoro**, Research Professor of Chemistry

**Otto Vogl**, Herman F. Mark Professor of Polymer Science

**Mary K. Cowman**, Associate Professor of Biochemistry

**Jovan Mijovic**, Associate Professor of Chemical Engineering

**Walter P. Zurawsky**, Associate Professor of Chemical Engineering

**Nitash Balsara**, Assistant Professor of Chemical Engineering

**Lawrence R. Dodd**, Assistant Professor of Chemical Engineering

**Iwao Teraoka**, Assistant Professor of Chemistry

**Kale Levon**, Assistant Professor of Chemistry

# SOCIAL SCIENCES

## UNDERGRADUATE PROGRAMS

Students working towards a Bachelor of Science degree in Social Sciences take a core curriculum in contemporary liberal arts, together with course concentrations chosen from history, history and philosophy of science and technology, economics, psychology and behavioral sciences (anthropology and sociology). This core curriculum was conceived to meet the increasing need for specialists in the social sciences who are also familiar with computers, the physical sciences and engineering, mathematics and the humanities. Students are offered specialized training in the social sciences in a setting at the Polytechnic noted for its scientific and technical excellence. The degree is interdisciplinary, with emphasis on developing integrated historical, economic, behavioral and cultural perspectives on human society.

Social science concentrations are useful in the following areas: teaching at all levels; applied research on problems involving race, gender, poverty, and education; urban and national planning; management, personnel operations and market research; environmental impact evaluation; foreign policy assessment; law; social work; and medicine. Social sciences also 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. Solid backgrounds in the social sciences prepare students for leadership in industry, education, and government.

### *HISTORY, AND HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLOGY*

Courses in history emphasize elements of social and economic change in various geographic areas and periods since the European 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. Students are also introduced to original documents and differing scholarly interpretations, and to the study of the non-Western world.

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, SS 104, stresses the conflicts of ideologies in the twentieth century and developments in non-Western societies. Students analyze and discuss the best historical scholarship in a variety of special courses, and methods of instruction include formal lectures, discussions, colloquia, films, and tutorials leading to independent research.

Students who major in the history and philosophy of science and technology benefit from one of the most comprehensive programs available in the New York area. Career openings for such majors may be found in government, 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, and in analyzing economic institutions and problems. These courses pose, in their theoretical and historical contexts, important questions of domestic and international public policy.

Candidates for the Social Sciences degree concentrating 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.

### *PSYCHOLOGY AND BEHAVIORAL SCIENCES (Anthropology and Sociology)*

Introductory courses in anthropology, sociology, and psychology broaden students' understanding of social processes and human behavior, and prepare them to meet professional and administrative problems with insight and sophistication.

Advanced 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. Other courses analyze language, learning and the modification of behavior, with experiments in perception, learning, and communication. Students become acquainted with a range of behavioral methods of scientific study, 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, which can be empirically investigated. The department offers advanced courses in applied, social, environmental, cognitive, developmental, personality, comparative, physiological, learning and abnormal psychology. All majors take a two-semester experimental psychology sequence, which offers fundamental methods and concepts in the empirical investigation of human and animal behavior in labora-

# SOCIAL SCIENCES

tory as well as field settings. 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 behavior, and social impact assessment, or to enter management training programs and paraprofessional work in such settings as youth centers, clinics, schools, community programs, etc.

An understanding of psychology is of particular use to engineers who must design devices and controls for safe and easy application by human beings. For engineers who become managers, psychology is useful in teaching the principles of human interaction.

## REQUIREMENTS FOR THE BACHELOR'S DEGREE IN SOCIAL SCIENCES

### LIBERAL ARTS CORE PROGRAM: PART I 34 Credits

HU 101/03	WRITING AND THE HUMANITIES I/WRITING AND THE HUMANITIES I (ENGLISH AS A SECOND LANGUAGE)	3
HU 200	WRITING AND THE HUMANITIES II	3
SS 104	MAIN THEMES IN CONTEMPORARY WORLD HISTORY	3
EG 101	INTRODUCTION TO ENGINEERING	3
HU 110/105	BASIC REPORT WRITING/ADVANCED COMPOSITION	3
HU 344	INTRODUCTION TO LOGIC	3
SS 138	TECHNOLOGY, SCIENCE, ETHICS AND CONTEMPORARY SOCIETY	3
CS 200	PROGRAMMING IN PASCAL	3
MA 106	CALCULUS I	4

PLUS SIX OR MORE CREDITS IN CM, PH, LS OR OTHER APPROPRIATE SCIENCE OR ENGINEERING SEQUENCE

### CORE PROGRAM: PART II 24 Credits

SS	WORLD HISTORY (Choose from SS 109, 120, 121, 123, 124)	3
SS	HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLOGY (Choose from: SS 135, 136)	3
SS	PSYCHOLOGY AND BEHAVIORAL SCIENCES (SS 189)	3
SS	ECONOMICS (SS 250)	3

HU	LITERATURE (Choose from: HU 212, 213, 222, 252, 283, 291)	3
HU	PHILOSOPHY (Choose from: HU 346, 347, 348, 349, 352, 353)	3
HU	ART (HU 382)	3
HU	MUSIC (HU 371)	3
	TOTAL CORE	58 CREDITS

	SOCIAL SCIENCES CONCENTRATION (see below for details)	36 CREDITS
	FREE ELECTIVES	26 CREDITS
	TOTAL REQUIRED FOR B.S.	120 CREDITS

## CONCENTRATIONS IN SOCIAL SCIENCES

Choose 12 courses (36 credits) in one of the following areas:

1. ECONOMICS
2. PSYCHOLOGY AND BEHAVIORAL SCIENCES
3. WORLD HISTORY
4. HISTORY AND PHILOSOPHY OF SCIENCE AND TECHNOLOGY

### 1. ECONOMICS

SS 251	MICROECONOMICS
SS 252	MACROECONOMICS
SS 254	ECONOMIC ISSUES
SS 255	THE CONTEMPORARY AMERICAN ECONOMY: BOOM AND BUST
SS 257	HISTORY OF ECONOMIC THOUGHT
SS 264	URBAN ECONOMICS
SS 265	MONEY & BANKING
SS 270	MANAGEMENT PROCESS
SS 275	FOUNDATIONS OF BUSINESS SYSTEMS
SS 304	GUIDED READINGS IN ECONOMICS
SS 354	TECHNOLOGICAL FORECASTING
SS 357	TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES
SS 363	LABOR ECONOMICS
SS 364	SPECIAL TOPICS IN ECONOMICS

### 2. PSYCHOLOGY AND BEHAVIORAL SCIENCES (ANTHROPOLOGY AND SOCIOLOGY)

SS 175*	INTRODUCTION TO SOCIOLOGY
SS 177*	SOCIAL PROBLEMS
SS 178	MINORITIES IN THE NEW WORLD
SS 182	MAN AND THE ENVIRONMENT
SS 184*	THE SOCIOCULTURAL SCIENCES
SS 185	ANTHROPOLOGY: PHYSICAL
SS 186	ANTHROPOLOGY: CULTURAL
SS 203	LEARNING
SS 204	PHYSIOLOGICAL PSYCHOLOGY
SS 206	HUMAN COGNITION

SS 208*	EXPERIMENTAL PSYCHOLOGY I
SS 209*	EXPERIMENTAL PSYCHOLOGY II
SS 210	ENVIRONMENTAL PSYCHOLOGY
SS 213	NORTH AMERICAN INDIANS
SS 214	SOCIAL PSYCHOLOGY
SS 215	ABNORMAL PSYCHOLOGY
SS 216	PERSONALITY DEVELOPMENT
SS 217	PSYCHOLOGY OF HUMAN DEVELOPMENT
SS 279	THE SOCIOLOGY OF HUMAN DISEASE
SS 299	ORGANIZATIONAL BEHAVIOR
SS 305	GUIDED READINGS IN PSYCHOLOGY
SS 306	GUIDED READINGS IN ANTHROPOLOGY AND SOCIOLOGY
SS 310	GENES, GENDER, AND SOCIETY
SS 365	SPECIAL TOPICS IN PSYCHOLOGY
SS 366	SPECIAL TOPICS IN ANTHROPOLOGY AND SOCIOLOGY

\*REQUIRED IN CONCENTRATION

### 3. WORLD HISTORY

SS 109	BIRTH OF MODERN EUROPE
SS 110	THE RENAISSANCE AND REFORMATION
SS 120	HISTORY OF TSARIST RUSSIA TO THE REVOLUTION
SS 121	HISTORY OF THE SOVIET UNION
SS 123	HISTORY OF THE UNITED STATES: FROM SETTLEMENTS TO RECONSTRUCTION
SS 124	HISTORY OF THE UNITED STATES: FROM RECONSTRUCTION TO THE COLD WAR
SS 135*	HISTORY OF SCIENCE AND TECHNOLOGY: ANTIQUITY TO GALILEO
SS 136*	HISTORY OF SCIENCE AND TECHNOLOGY: GALILEO TO DARWIN
SS 137*	HISTORY OF SCIENCE AND TECHNOLOGY: FARADAY TO THE PRESENT
SS 151	INTRODUCTION TO POLITICS
SS 161	POLITICS & FILM (May be repeated for credit)
SS 221	THE END OF THE U.S.S.R.: GORBACHEV AND AFTER
SS 226	PROBLEMS OF AMERICAN FOREIGN POLICY
SS 229	GROWTH OF THE UNITED STATES CONSTITUTION
SS 302	GUIDED READINGS IN HISTORY
SS 362	SPECIAL TOPICS IN HISTORY
SS 363	SPECIAL TOPICS IN HISTORY OF SCIENCE AND TECHNOLOGY

\*STUDENT MUST CHOOSE 2 OF THESE COURSES

### 4. HISTORY AND PHILOSOPHY

**OF SCIENCE AND TECHNOLOGY**

- SS 109\* *THE BIRTH OF MODERN EUROPE*
- SS 110\* *THE RENAISSANCE AND REFORMATION*
- SS 133 *ARCHAEO- AND ETHNOASTRONOMY*
- SS 135\* *HISTORY OF SCIENCE AND TECHNOLOGY: ANTIQUITY TO GALILEO*
- SS 136\* *HISTORY OF SCIENCE AND TECHNOLOGY: GALILEO TO DARWIN*
- SS 137\* *HISTORY OF SCIENCE AND TECHNOLOGY: FARADAY TO THE PRESENT*
- SS 182 *MAN AND THE ENVIRONMENT*
- SS 303 *GUIDED READINGS IN HISTORY OF SCIENCE AND TECHNOLOGY*
- SS 332 *SCIENCE AND TECHNOLOGY IN AMERICA*
- SS 333 *MEDIEVAL AND RENAISSANCE ENGINEERING*
- SS 338 *GALILEO GALILEI: THE MAN, HIS RESEARCH, THE TIMES*
- HU 352\* *PHILOSOPHY OF SCIENCE*
- HU 353\* *PHILOSOPHY OF TECHNOLOGY*
- SS 354 *TECHNOLOGICAL FORECASTING*
- SS 357 *TECHNOLOGY TRANSFER TO DEVELOPING COUNTRIES*
- SS 363 *SPECIAL TOPICS IN HISTORY OF SCIENCE AND TECHNOLOGY*

\*REQUIRED

**UNDERGRADUATE COURSES**

**HISTORY AND HISTORY OF SCIENCE AND TECHNOLOGY**

*PREREQUISITE FOR ALL COURSES: SS 104*

**SS 104 Main Themes in Contemporary World History 3:0:0:3**

Examination of the major ideologies, transformations, and tensions marking the contemporary age, from World War I to the last decade of the 20th Century. Readings, lectures, discussion, with feature and documentary films on such topics as: the World Wars and Cold Wars; the rise, and now the fall of, Communism in Eastern Europe and the U.S.S.R.; the development of American

globalism; the awakening of the Third World and the end of European Imperialism; the scientific-technological revolutions in war and in peace; current crises. Required of all students at Polytechnic.

**SS 109 The Birth of Modern Europe, The Early Phase, 800-1500 3:0:0:3**

From the time of the first stirring of specifically Western European Civilization, through its initial expansion and consolidation in the High Middle Ages, to the beginnings of the next great expansion marked by a peculiar dynamism probably linked to the nature of its material, human, institutional and spiritual resources. How those resources evolved over the years, and how Europeans used them to create the foundations for the institutions and patterns of functioning that still characterize the West today.

**SS 110 The Renaissance and Reformation 3:0:0:3**

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 120 History of Tsarist Russia to Revolution 3:0:0:3**

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 3:0:0:3**

Revolutions of 1917; Leninism in power; industrialization, collectivization, ascendancy of Stalin; Soviet Union and West — from alliance to Cold Wars; Khrushchev and de-Stalinization; Soviet impact on underdeveloped world; the Brezhnev era and the crisis of Soviet society.

**SS 123 History of the United States:**

**From Settlements through Reconstruction 3:0:0:3**

Indigenous civilizations in North America. Culture, politics and society from European and African-American settlements through post-Civil War era. Interpretation of accessible "primary sources," which illuminate convictions, ideologies and activities of leaders as well as ordinary Americans from the 17th through the mid-19th century.

**SS 124 History of the United States: From Reconstruction through the Cold War 3:0:0:3**

The transformation of the post-Civil War U.S. to a nation of global authority; interweaving of domestic struggles and foreign policies from the "Gilded Age", through the Progressive Era; the World Wars of the 20th century; the New Deal period and post-New Deal domestic policy conflicts. U.S. foreign policy in a world of revolutionary upheavals.

**SS 133 Archaeo- and Ethnoastronomy 3:0:0:3**

Early astronomical knowledge and its place and uses in all cultures to keep track of the motions of celestial bodies (excluding only the astronomies of Graeco-Alexandrian antiquity forward; see SS 135). The astronomical knowledge per se of several quite different cultures and the ways in which these astronomies both reflected and reinforced the economic and social organization and the cosmological and religious beliefs of the cultures in which they were embedded. Instruction in elementary, naked-eye astronomy, exercises in designing simple instruments and, weather permitting, actual observation. Student work will include a term project.

**SS 135 History of Science and Technology: Antiquity through Galileo 3:0:0:3**

Science and technology from earliest time to Renaissance: neolithic and medieval technologies; achievements of ancient Greeks from pre-Socratics 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**

## SOCIAL SCIENCES

### **Technology: Galileo through Darwin** 3:0:0:3

Science and technology from the scientific revolution through Lavoisier 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 Technology: Faraday Through Present** 3:0:0:3

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, Ethics, and Contemporary Society** 3:0:0:3

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 and ethical issues posed by restricted and unrestricted uses of technology and science.

### **SS 151 Introduction to Politics** 3:0:0:3

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 161 Politics and Film** 3:0:0:3

Film viewed as historical document and political instrument. Film as facet of mass culture and mass communication and means of shaping and reflecting attitudes and values. Each of the historically framed subjects constitutes a separate course for credit. Topics include: Depression America; 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,

1947-1962. Film screenings, readings, lectures and discussions. Other topics offered as appropriate. May be repeated for credit.

### **SS 221 The End of the U.S.S.R.: Gorbachev and After** 3:0:0:3

The U.S.S.R. under Gorbachev, 1985-1991, and the crisis that led to the collapse of Soviet Communism. The historical background: from Khrushchev's deStalinization to Brezhnev's stability and stagnation. Gorbachev's "glasnost" and "perestroika" as reform strategies out of the crisis. The unforeseen consequences of the Gorbachev reforms: The end of the U.S.S.R. Culture, politics, and economy to the present. Films, lectures, readings.

### **SS 226 Problems of American Foreign Policy** 3:0:0:3

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 229 Growth of the United States Constitution** 3:0:0:3

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 332 Science and Technology in America** 3:0:0:3

Colonial science. Indifference to basic science during 19th century. Technology and industrialization. Recent accomplishments of American science and technology. Emergence to superpower status.

### **SS 333 Medieval and Renaissance Engineering** 3:0:0:3

Engineering and technological enterprise in the European High Middle Ages and Renaissance, roughly 1000 to 1600. The period was characterized by a growing

capacity to handle complex engineering tasks such as the building of the Gothic cathedral, the mining of ores, the extraction of metals, the industrial production chemicals (e.g., gunpowder), the building of bridges and digging of canals, the construction of ships and the design of complex machinery, both light and heavy duty. Organizing a given project or task, the means of financing, the political and institutional involvement, and the training of the artisan-engineer and his position in society.

### **SS 338 Galileo Galilei: the Man, his Research, the Times** 3:0:0:3

The life and career of one of the pivotal founders of modern science, Galileo Galilei (1564-1642). Galileo's experimental/observational researches and the genesis and development of his mature conclusions in physics and cosmology. His role in establishing new attitudes towards the investigation of natural phenomena, his conflict with the Church, the work of his predecessors and contemporaries and the setting: Italy in the late 16th and early 17th centuries. Students will have the opportunity of empirically investigating some of Galileo's experiments.

### **SS 354 Technological Forecasting** 3:0:0:3

Introduction to problems associated with technology forecasting. Short range, intermediate, and long-range forecasting methodologies. Forecasting social and economic consequences of adopted innovations. Students will prepare a forecast on a topic of their choice.

### **SS 357 Technology Transfer to Developing Countries** 3:0:0:3

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 industrialized countries. **Also listed under IE 357**

**PSYCHOLOGY AND  
BEHAVIORAL SCIENCES  
(ANTHROPOLOGY AND  
SOCIOLOGY)**

*Prerequisite for all courses:  
SS 189 or SS 184*

**SS 175 Introduction to Sociology**  
3:0:0:3

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 environmental crises; the human impact of technology.

**SS 177 Social Problems** 3:0:0:3

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 182 Man and the Environment:  
Environmental Science I** 3:0:0:3

Ecological understanding of interactions of human with non-human 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 184 The Sociocultural Sciences**  
3:0:0:3

Introduction to the nature of anthropological and sociological discourse and explanation. Society and biology in human collective behavior. Demography and social behavior. The concepts of culture and society. Classical anthropological and sociological studies — Kroeber, Boas, Spencer, Durkheim, Weber, and Merton. Sociological and anthropological perspectives on language.

**SS 185 Anthropology: Physical**  
3:0:0:3

Biosocial bases of human conduct seen in evolutionary perspectives; elementary genetic, demographic and ecological models necessary for understanding human behavior; biology as an evolutionary complex extending from prosimian revolution through neolithic revolution.

**SS 186 Anthropology: Cultural**  
3:0:0:3

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 189 Introduction to Psychology**  
3:0:0:3

Scientific study of behavior. Learning, physiological psychology, sensory systems, developmental, educational, abnormal and social psychology. Lectures, class discussion, films/videos, demonstrations of experiments.

**SS 203 Psychology of Learning**  
3:0:0:3

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.

**SS 204 Physiological Psychology**  
3:0:0:3

Relationships among physiology, anatomy, and behavior. Physiological, anatomical, and biochemical bases for memory, learning, motivation, sleep, arousal, and stress.

**SS 205 Applied Psychology** 3:0:0:3

How various problems, particularly in work, can be solved through the judicious use of psychological principles. Human-machine interaction and other engineering-behavior interactions, smoking, study habits, memory, creative thinking, group inter-action, raising children, influencing people, self-control, and specific problems brought up in class by students. Students select a problem, do a behavioral analysis and finally modify it as a class project.

**SS 206 Human Cognition and  
Information Processing** 3:0:0:3

Human cognitive and information processing capabilities: Structures of memory and internal representations of knowledge, concept formation and schemas, symbol manipulation, mental operations, consciousness, and problem-solving capabilities and strategies. Implications for learning, development, language acquisition, and Artificial Intelligence.

**SS 208 Experimental Psychology I**  
3:0:0:3

Theory and methods of measurement of sensory functions in human and animal subjects. Examination of the concept of the threshold and problems of its measurement. Investigation of learning, both motor and verbal, and both simple and complex, including problem solving and creative thinking. Students will perform a series of experiments with human and animal subjects.

**SS 209 Experimental Psychology II**  
3:0:0:3

Experimental and descriptive methods including quasi-experimental design and large scale survey techniques used by social, environmental, and developmental psychologists to assess human behaviors in laboratory and naturalistic settings. The course focuses upon laboratory and observational methods used to assess environmental effects, attitude measurement, social impact assessment, and theory and psychometric bases of normal personality development and assessment.

## SOCIAL SCIENCES

### SS 210 Environmental Psychology 3:0:0:3

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.

### SS 213 North American Indians 3:0:0:3

A survey of the cultures of selected Indian and Eskimo groups. After a general historical introduction primary emphasis will be placed on tribal social organization, technology, art, and language at the time of European contact.

### SS 214 Social Psychology 3:0:0:3

Behavior as function of social stimulation. Nature of socio-psychological 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.

### SS 215 Abnormal Psychology 3:0:0:3

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.

### SS 216 Personality Development 3:0:0:3

Methods and theory relevant to the study of personality. Personality development in terms of social learning, development, and cognition. Examples of personality research include studies of authoritarianism, achievement motivation, self-esteem, sex-role acquisition and stereotyping, family and life style choices, and effects of physiological variables including maturity and aging.

### SS 217 Psychology of Human Development 3:0:0:3

Human development from birth to old age. Effects of age on thinking, learning, social behavior. Implications for teaching and educational programs.

### SS 279 The Sociology of Human Disease 3:0:0:3

Human disease in context of social and biological adaptation. Disease profiles of the three major levels of social evolution (hunters and gatherers, low-energy agriculturalists, and states) considered from broadly conceived human ecological viewpoints. Recommended: some background in biology and anthropology.

### SS 299 Organizational Behavior 3:0:0:3

Behavior in industrial settings. Informal and formal group dynamics: Interpersonal relationships, supervision, leadership, communication theories, attitude measurement, creativity. Analyses of administration problems through case studies and simulated situations. **Also listed under MG 301**

### SS 310 Genes, Gender, and Society 3:0:0:3

Psychology, sociology, and anthropology of men and women's relationships to one-another and to society. Biological, societal, and psychological bases of sex-role differentiation and acquisition. Implications of historical, cultural, economic, and psychological factors for contemporary women's and men's lifestyles, sexuality, roles, economic status, and political power.

## ECONOMICS

*Prerequisite for all courses: SS 250*

### SS 250 Basic Economics 3:0:0:3

Basic micro- and macroeconomics. Supply and demand. Markets and market structure. Income distribution. Market failures. National output. Aggregate supply and aggregate demand. Unemployment and inflation. Fiscal and monetary policy.

### SS 251 Microeconomics 3:0:0:3

Advanced supply and demand analyses. Allocation of resources and distribution of income. Various market structures: perfect competition, imperfect competition, oligopoly and monopoly. Externalities. Government and the market.

### SS 252 Macroeconomics 3:0:0:3

Advanced national income analysis. Employment and unemployment, inflation and growth. The federal government and fiscal policy, the Federal Reserve Board and monetary policy. International trade and the balance of payments.

### SS 254 Economic Issues 3:0:0:3

An intensive study of a number of the following: Unemployment and inflation, urban fiscal crises, racial and sexual discrimination, pollution, poverty, imperialism and military spending. Production and consumption and the role of the state.

### SS 255 The Contemporary American Economy: Boom and Bust 3:0:0:3

The current economy: inflation, unemployment, growth and recession. Interest rates, money, the stock market, wages, productivity, profit rates and the balance of payments. Role of military expenditures. Legacies of the Vietnam and Gulf Wars. Evaluations of the Federal Reserve and government spending; taxation, deficits and monetary policy. Supply side economics. Wage-price controls, unions and the future of economic planning.

### SS 257 History of Economic Thought 3:0:0:3

Development of economic thought. Various schools of thought which anticipated and prefigured modern economic analysis.

### SS 264 Urban Economics 3:0:0:3

Contemporary American cities and changing functions. Interrelation 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 3:0:0:3**

Nature of money, gold and paper standards; commercial banks and Federal Reserve system, financial institutions; balance of payments, exchange rates, international monetary order. Money, prices, inflation, business fluctuations. Domestic and international monetary policy. Problems and changes in the U.S. banking system.

**SS 270 Management Process 3:0:0:3**

Introductory management course for undergraduates. Primary focus is the management process: planning, organizing, staffing, controlling, directing and decision making. Attention is given to the roles of various disciplines within management as well as to the traditional business functions of marketing, accounting, finance, production, engineering, and research development. Also listed under MG 300

**SS 275 Foundations of Business Systems 3:0:0:3**

This course provides the student with a systems perspective on the specification, development, implementation, and maintenance of organizational information technology. Also listed under MG 305

**SPECIAL TOPICS AND GUIDED STUDIES****SS 302-306 Guided Readings in Social Sciences each 3:0:0:3**

Selected problems in history, history of science and technology, economics, anthropology, sociology, psychology, politics, interdisciplinary studies. Individual or group projects under faculty supervision involving guided reading and/or research. For mature students wishing to undertake specialized, independent study under tutorial guidance. Prerequisite: junior standing or department's permission. Agreement of instructor required before registration.

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.

*each 3:0:0:3***SS 361 Special Topics in Social Sciences****SS 362 Special Topics in History****SS 363 Special Topics in History of Science and Technology****SS 364 Special Topics in Economics****SS 365 Special Topics in Psychology****SS 366 Special Topics in Anthropology and Sociology**

In addition to the above regularly scheduled courses, the Department offers the following from time to time (*all 3 credits each*):

**SS 101 History of Western Civilization 1500-1815****SS 102 History of Western Civilization 1815-1914****SS 116 History of Latin America****SS 126 African-American History****SS 128 History of Jazz****SS 154 Russia, China, and the West****SS 262 Collective Bargaining****SS 263 Labor Economics****SS 267 The Market for Engineers and Scientists****SS 330 History and Environment****SS 345 Colloquium in Twentieth Century Thought****SS 347 Colloquium in Imperialism****SS 348 Colloquium in The History of Socialism and Communism****SS 358 Human Resource Development in Advanced Developing Countries****FACULTY**

**Louis Menashe**, Professor of History and Head 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 post-Soviet history, cinema and society*

**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, Asia, Central America, U.S. Foreign Policy*

**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*

**David Mermelstein**, Professor of Economics  
B.A., Amherst College; Ph.D., Columbia University  
*Political Economy, Macroeconomic Policy, Money and Banking*

**Thomas B. Settle**, Professor of History of Science and Technology  
B.A., M.A., Ph.D., Cornell University  
*Galilean Studies, the Italian Renaissance, engineering in Medieval and Renaissance Europe.*

**Pamela E. Kramer**, Associate Professor of Psychology  
B.A., Bryn Mawr College, M.Ed., M.S., Tufts University; Ph.D., Yeshiva University  
*Psychology of women, human cognition, psycholinguistics and developmental psychology.*

## SOCIAL SCIENCES

**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 Muleahy**, Associate Professor of Anthropology  
B.A., M.A., Ph.D., University of Massachusetts  
*Marginal communities, human ecology, cultural symbolism, language and culture*

**Romualdas Sviedrys**, Associate Professor of History of Technology  
B.A., Cornell University; Licenciado, Universidad Nacional (Colombia); Ph.D., Johns Hopkins University  
*Technology forecasting and technology assessment, history of technology and science since 1750, technology transfer to developing countries*

**Richard E. Wener**, Associate 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*

**Donald Phillips**, Instructor in Psychology  
B.S., Polytechnic Institute of New York  
*Experimental and physiological psychology, physical anthropology, paleontology*

### ADJUNCT FACULTY

**Barbara Bienstock**, Lecturer in Psychology  
B.A., Ph.D., Queens College

**Mark D'Amato**, Lecturer in Economics and Contemporary History  
B.A., New York University; MA, Ph.D., The New School for Social Research

**Sheila Lehman**, Lecturer in Psychology  
B.A., Barnard College; M.A., Columbia University

**Malcolm McCullough**, Lecturer in Psychology  
B.S., Polytechnic Institute of New York; Ph.D. Queens College

### EMERITUS FACULTY

**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*

# SYSTEMS ENGINEERING

Systems engineering is based on the body of theoretical knowledge that underlies the engineering of modern complex systems. Systems 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 systems engineer may receive assignments crossing traditional lines of engineering applications. Systems engineering is presently applied in areas such as transportation, urban services, bioengineering, resource management, power and energy, and environmental and pollution control.

The program in systems 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 computers. The systems 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 administers the program leading to the degree of master of science in systems engineering. Outstanding students should apply for financial aid in the form of research fellowships, teaching fellowships or partial tuition remission.

Students wishing to continue graduate study towards a Ph.D. in the area of systems may do so in the Electrical Engineering Program.

## REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREE

The entrance requirement for the master of science in systems 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 systems 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.

### 1. Core Courses

Three courses from among the following:

EL 630	<i>Probability</i>
EL 625	<i>Linear Systems</i>
EL 611	<i>Signals, Systems and Transforms</i>
EL 613	<i>Applied Matrix Theory</i>
EL 621	<i>Feedback Control I</i>
MA 861	<i>Statistical Inference I</i>

9 Units

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 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 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 EE Department 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.

## GRADUATE COURSES

### SE 997 Thesis for Degree of Master of Science in Systems 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 Systems 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). The program for a Degree of Engineer is being phased out, so that this course is only for students entering the program prior to September 1993. *Prerequisite: Degree status.*

**FACULTY**

**Joseph J. Bongiorno, Jr.**, Professor of Electrical Engineering

**Richard A. Haddad**, Professor of Electrical Engineering

**Walter Helly**, Professor of Operations Research

**Farshad Khorrani**, Assistant Professor of Electrical Engineering

**William R. McShane**, Professor of Industrial and Systems Engineering

**Philip E. Sarachik**, Professor of Electrical Engineering

**Leonard G. Shaw**, Professor of Electrical Engineering and Dean of School of Electrical Engineering and Computer Science

**Martin L. Shooman**, Professor of Electrical Engineering and Computer Science

**Peter Voltz**, Associate Professor of Electrical Engineering

**Joachim I. Weindling**, Professor of Operations Research and Systems Engineering

**Dante C. Youla**, University Professor

# TELECOMMUNICATIONS AND COMPUTING MANAGEMENT

The Department of Management of the Polytechnic University, supported by the school of Electrical Engineering and Computer Science in conjunction with the Center for Advanced Technology in Telecommunications (CATT) offers a master of science program in telecommunications and computing management.

This program was started in 1984 with the express purpose of providing education for executives faced with new challenges and opportunities in the rapidly developing areas of telecommunications and computing. The Master of Science in Telecommunications and Computing Management is a rigorous two-year, four-semester program consisting of 12 courses and an independent research project.

The curriculum was developed by CATT and senior faculty in conjunction with a private sector advisory board.

The board's current functions are to:

- (i) monitor the effectiveness of the program,
- (ii) help keep the detailed course syllabi current, and
- (iii) propose changes in the program in light of experience.

The philosophy of the program is to provide a solid foundation in telecommunications and computing technology and management in the initial semesters of the program, followed in the final year by coursework integrating technology and management skills. Case studies, practical exercises, and research investigations are used throughout the program.

Students are experienced working professionals in telecommunications and computing. About half the students are employed by providers of telecommunications and computing services, and the other half by users of these services.

The program is given in an *executive format*, that is, classes meet every other week for two full days, Friday and Saturday at Polytechnic's Westchester Center at Hawthorne, New York. Breakfast, lunch, and coffee breaks are provided.

All classes are videotaped with tapes made available for viewing on campus or at home.

An all-inclusive fee covers tuition and fees, textbooks and other educational material, special tutorials and lectures, meals on class days, and access to videotapes of all classes and lectures.

## ADMISSION REQUIREMENTS AND APPLICATION INFORMATION

Admission to the program requires a baccalaureate degree from an accredited institution with a superior undergraduate academic record, a minimum of two years work experience in the field of telecommunications and/or computing, and employer support.

Applications for admission are accepted throughout the year, but admission is for fall semesters only. Because enrollment is limited, early application is strongly recommended.

## DEGREE REQUIREMENTS AND CURRICULUM

The general requirements for Master of Science degrees stated elsewhere in this catalog apply to this program. The curriculum consists of 12 courses (36 units) which are taken by every student, plus an independent research project which must be completed during the second year of the program. There are no elective courses in this program.

The 12 courses which constitute the program curriculum are:

### FALL

#### First Semester

- EL 535 *Elements of Communication Networks*  
MG 600 *Management Process*  
MG 609 *Managerial Accounting and Finance*

### SPRING

#### Second Semester

- EL 635 *Principles of Communications Networks*  
MG 652 *Telecommunications Regulation, Policy, and Law*  
MG 820 *Project Management*

### FALL

#### Third Semester

- EL 735 *Communications Networks*  
MG 607 *Marketing Management*  
MG 654 *Economics of Information Systems*

### SPRING

#### Fourth Semester

- CS 682 *Network Management and Security*  
MG 650 *Management of Information Systems*  
MG 970 *Business Policy and Strategy*

## COURSE DESCRIPTIONS

The courses described below are unique to this program and cannot be applied to any other degree program. For other course descriptions, refer to the appropriate other sections of this catalog (Management, Electrical Engineering, Computer Science).

### MG 609 Managerial Accounting and Finance *3 units*

Aspects of accounting and finance of practical use to the manager. Relations among accounting, economic, and financial perspectives. Analysis of principles and practices of the finance function, and its application in organizations.

## **MG 652 Telecommunications Regulation, Policy, and Law** 3 units

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 965 Independent Research Project** 3 units

During the second year each student completes an independent, applied research project on a topic of practical importance to his/her employer. The purpose of the project is to give students an opportunity to apply and integrate the subjects taught in the program by working directly with a faculty member.

### FACULTY

**A. George Schillinger**, Professor of Management  
B.E.E., City College of New York;  
M.S., Eng., Ph.D., Columbia University  
*General management, technology management, corporate strategy.*

**Richard Van Slyke**, Professor of Electrical Engineering and Computer Science  
B.S., Stanford University; Ph.D., University of California at Berkeley  
*Computer communications, telecommunications.*

**Byron David**, Assistant Professor of Management;  
B.A., Queens College of CUNY; M.S., Polytechnic Institute of New York; M.B.A., Ph.D., Baruch College, CUNY  
*Operations management.*

**Nancy J. Needham**, Industry Professor of Management  
Academic Director, Telecommunications and Computing Management program  
B.A., Wellesley College;  
M.B.A., D.B.A., Harvard University  
*International telecommunications and financial services.*

### ADJUNCT FACULTY

**Kenneth Gross**, Adjunct Professor of Management;  
B.A., J.D., American University

**Aaron Kershenbaum**, Adjunct Professor of Computer Science  
B.S., M.S., Polytechnic Institute of Brooklyn; Ph.D., Polytechnic Institute of New York

**E. Hart Rasmussen**, Adjunct Professor of Management  
Director, Management Programs.  
Westchester Graduate Center  
B.S., M.S., Technical University of Denmark

**Teresa C. Rubinson**, Adjunct Professor of Computer Science.  
B.S., University of Illinois; M.B.A., Iona College; Ph.D., Polytechnic University

**R. Joseph Schlosser**, Adjunct Professor of Management  
B.A., Notre Dame; M.Ed., University of Massachusetts; Ph.D., Wharton School

**Andrew Snow**, Adjunct Professor of Electrical Engineering  
B.S., M.S., Old Dominion University

# TRANSPORTATION

Polytechnic offers graduate degree programs in transportation, leading to the degrees of:

## Master of Science

- Transportation Planning and Engineering
- Transportation Management

## Doctor of Philosophy

- Civil Engineering (Subtitle: Transportation Planning and Engineering)

The MS degrees are practice-oriented, with a strong foundation in underlying principles and methods. The MS (Transportation Management) is available only to part-time students.

The Transportation Program is housed within the Department of Civil and Environmental Engineering, which also provides a program in highway engineering as part of the master's degree in civil engineering.

Students and continuing professionals from a variety of disciplines undertake studies in transportation to lead to careers in transportation operations, design, planning, 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, 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.

## GENERAL REQUIREMENTS

## ADMISSION REQUIREMENTS

To be eligible for admission as graduate students, applicants must hold at least a baccalaureate degree from an acceptable institution. Students pursuing the "transportation planning and engineering" degrees are expected to have the stronger quantitative background, usually with prior degrees in engineering, mathematics, or the physical sciences.

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 students have 3.0 grade point averages or better in all graduate courses and in all guided studies (readings, projects, theses, dissertations). Averages are separately computed 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. If the student has not had a statistics course, one can be taken prior to admission or the student will be required to take a two-day Saturday course in statistics given by the transportation faculty at Polytechnic, for which no graduate credit is given.

All applicants for certificate programs must meet the same entrance requirements as Master of Science applicants.

All applicants for the Ph.D. degree 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.

# TRANSPORTATION

## COMPUTER LITERACY

Students will be exposed to uses of computers and computer packages in transportation integrated into the curricula. Emphasis is on personal and micro-computers. Students will use packages in highway capacity, traffic signal timing and coordination, and transportation assignment (MINUTP, TRANSPLAN, TRANSCAD, and MAPINFO) in required coursework. The Department has its own computer laboratory, using IBM and IBM compatible micro-computers. Students also have access to Polytechnic's CAD/CAM system and 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 student's 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.

Students studying under research fellowships are assigned research advisers, normally the principal investigators of the projects which fund the fellowships.

While academic advisers consult with and give advice to students, students must ensure that requirements are fulfilled and submit all proper forms and applications when necessary.

## REQUIREMENTS FOR THE MASTER OF SCIENCE DEGREES

The Transportation Program has M.S. degrees in transportation planning and engineering, and transportation management; each require 36 units, of which 27 must be taken in Polytechnic graduate courses.

Fifteen units are in a common core shared by the two M.S. degrees. Each M.S. degree has an additional twelve units of required courses, suited to the orientation of the degree. The remaining nine units is completed by electives approved by the assigned academic adviser.

Full-time students, particularly those studying under research fellowships, may be required to do a project for which they receive three or more units as part of their electives.

<b>Common Core</b>		<b>Units</b>
TR 605	<i>Travel Demand Forecasting</i>	3
TR 607	<i>Urban Transportation Planning and Congestion Management</i>	3
TR 629	<i>Transportation Workshop</i>	3
TR 660	<i>Urban Public Transportation</i>	3
TR 750	<i>Transportation Economics and Finance</i>	3
		15

### Other M.S. (TP&E) Requirements

TR 606	<i>Computer Applications for Transportation Planning</i>	3
TR 701	<i>Traffic Engineering I</i>	3
TR 702	<i>Traffic Engineering II</i>	3
TR 710	<i>Design of Traffic Facilities</i>	3
		12

### Other M.S. (TM) Requirements

TR 759	<i>Transportation Policy</i>	3
TR 760	<i>Management of Transit Maintenance and Operations</i>	3
CE 828	<i>Project Planning and Control</i>	3
IE 645	<i>Productivity Management</i>	3
		12

## ELECTIVES FOR THE TRANSPORTATION M.S. DEGREES

All electives require approval of the assigned academic adviser. Below are examples of pre-approved electives that may be taken for each of the degrees.

### Transportation Planning and Engineering

TR 665	<i>Design of Rail Facilities</i>
TR 670	<i>Planning and Design of Terminals</i>
TR 671	<i>Airport Planning and Design</i>
TR 672	<i>Port Planning and Design</i>
TR 703	<i>Computer Applications and Analytic Techniques in Traffic</i>
TR 704	<i>IVHS</i>
TR 722	<i>Highway Pavement Design</i>
TR 723	<i>Design and Management of Highway Structures and Materials</i>
TR 865	<i>Traffic Safety Engineering</i>

### Transportation Management

TR 665	<i>Design of Rail Facilities</i>
TR 671	<i>Airport Planning and Design</i>
TR 672	<i>Port Planning and Design</i>
TR 703	<i>Computer Applications</i>
TR 704	<i>IVHS</i>
MG 600	<i>Management Process</i>
MG 613	<i>Organizational Behavior</i>
CE 781	<i>Analysis of Public Works</i>
CE 830	<i>Information Systems in Project Management</i>

## TRANSFER CREDITS

A total of 36 units is required for the M.S. degrees in TP&E and in TM.

The residency requirement for M.S. degrees is 27 units, which means that a 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 on a 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 are not included in computing grade point average. Validation credits by examination may not be used for any transportation degree.

**DUAL DEGREE PROGRAM WITH NYU**

The transportation program at the Polytechnic has a dual degree program with the Robert F. Wagner Graduate School of Public Service 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.

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 Robert F. Wagner Graduate School of Public Service, 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.

**DOCTOR OF PHILOSOPHY DEGREE IN TRANSPORTATION PLANNING AND ENGINEERING**

The Ph.D. in Civil Engineering with a concentration in transportation planning and engineering requires 90 units of graduate study beyond the bachelor's degree. The 90 units are made up of the

following:

1. A 30-unit major in transportation 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 a written and oral portion. The written portion is five hours long. Only those students that pass the written portion are invited to take the oral portion of the examination. Copies of previous examinations are available on request from the Program 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.

There is no foreign language requirement.

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. Outside committee members with suitable backgrounds are permitted, from other universities or from industry.

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. Students 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 Transportation Program 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.

# TRANSPORTATION

The Transportation Program offers the following certificates:

## Traffic Engineering Certificate

**Required: 15 Units**

- TR 701 *Traffic Engineering I*
- TR 702 *Traffic Engineering II*
- TR 703 *Computer Applications and Analytic Techniques in Traffic and Transportation*
- TR 670 *Planning and Design of Terminals*
- TR 710 *Design of Traffic Facilities*

## Transportation Planning Certificate

**Required: 15 Units**

- TR 605 *Travel Demand Forecasting*
- TR 606 *Computer Applications for Transportation Planning*
- TR 607 *Urban Transportation Planning*
- TR 701 *Traffic Engineering I*
- TR 702 *Traffic Engineering II*

## Transportation Facility Design and Operation Certificate

**Required: 15 Units**

- TR 670 *Planning and Design of Terminals*
- TR 701 *Traffic Engineering I*
- TR 710 *Design of Traffic Facilities*

Plus two of:

- TR 660 *Urban Public Transportation*
- TR 665 *Design of Rail Facilities*
- TR 671 *Airport Planning and Design*
- TR 672 *Port Planning and Design*
- TR 722 *Highway Pavement Design*
- TR 723 *Design and Management of Highway Structures and Materials*

## Public Transportation Certificate

**Required: 15 Units**

- TR 660 *Urban Public Transportation*
- TR 759 *Transportation Policy*
- TR 760 *Management of Transit Maintenance and Operations*

Plus two of:

- TR 607 *Urban Transportation Planning and Congestion Management*
- TR 670 *Planning and Design of Terminals*
- TR 750 *Transportation Economics and Finance*

## Transportation Management and Economics Certificate

**Required: 15 Units**

- TR 660 *Public Transportation*
- TR 750 *Transportation Economics and Finance*
- TR 759 *Transportation Policy*
- TR 760 *Management of Transit Maintenance and Operations*

Plus one of:

- 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.

Course substitution in certificate programs are permitted with the written approval of the assigned academic adviser.

## UNDERGRADUATE COURSES

The Program offers an undergraduate course in traffic engineering, which is required for the BS(CE) and may be used as a technical elective where approved by advisers, or as a free elective. 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.

### TR 360 Traffic Engineering 3:0:0:3

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. Also listed as CE 352*

## GRADUATE COURSES

### TR 605 Travel Demand Forecasting 2½:0:0:3

Theory and application of travel forecasting methods to predict the amount and nature of travel on transportation systems. **Also listed under CE834.**

### TR 606 Computer Applications for Transportation Planning 2½:0:0:3

This course covers the practical use of computers for urban transportation planning with a major focus on the tradition-

al four-step process (Trip Generation, Trip Distribution, Mode Choice, Trip Assignment). The emphasis will be on the use of the TRANPLAN package: a comprehensive transportation planning software for Highway and Public Transit Systems. Other areas of application will include spreadsheets (Quattro Pro), SPSS, and MAPINFO for data analysis. *Prerequisite/co-requisite: TR 605 or equivalent.*

### TR 607 Urban Transportation Planning and Congestion Management 2½:0:0:3

This course covers the theory and practice of urban Transportation Planning with a major focus on the methods and techniques for alleviating traffic congestion through transportation system management and travel demand management. Areas of application will include travel corridors, major activity centers, and residential neighborhoods. This is a "hands on" "how-to" course. *Prerequisite: TR 605.*

### TR 629 Transportation Workshop 0:5:0:3

Comprehensive projects designed to assure student's understanding of basic principles and their applications, drawing 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. *Prerequisite for M.S. (TP&E) students: TR 601 and TR 701. Co-requisite: TR 702. Pre- or Co-requisites for M.S. (TM) students: IE 620, TR 750, TR 660. Also listed under CE836.*

### TR 660 Public Transportation 2½:0:0:3

Needs for public transportation in urban areas. Characteristics of public transportation services: commuter rail, rail transit, light rail transit, express and local buses, commuter paratransit modes, taxi and other paratransit services. Planning and operations of transit routes and systems. Transit service performance measures. Functional design of transit stations, park and ride facilities, and transit rights-of-way. **Also listed under CE837.**

**TR 665 Design of Rail Facilities**  
2½:0:0:3

Design of systems for moving passengers and freight on rails. Roadbeds, alignment, yard, stations, signal communications, and protection devices. Design of light-rail transit facilities. **Also listed under CE838.**

**TR 670 Planning and Design of Terminals**  
2½:0:0:3

Passenger and freight terminals, with emphasis on system descriptions of these facilities. Land, marine, and air terminals. Methods for determining levels of service for pedestrians flow, TOFC and truck terminals are also covered. **Also listed under CE 840.**

**TR 671 Airport Planning and Design**  
2½:0:0:3

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 selections, configuration and economics. **Also listed under CE 841.**

**TR 672 Port Planning and Design**  
2½:0:0:3

Planning of marine terminal facilities for freight and passengers. Harbor and port capacity analysis. Functional design and control of ports. U.S. port terminal needs for containers and bulk freight. Port operations. **Also listed under CE839.**

**TR 701 Traffic Engineering I**  
2½:2½:0:3

First course in a two-semester sequence covering the basic aspects of traffic engineering. Driver, roadway, vehicle, and traffic stream characteristics, and their influence on operations, controls, and design. Traffic studies and data analysis: volume, speed, delay, density, accidents, etc. Concept of traffic capacity and level of service analysis. Capacity and level of service analysis of limited access

facilities: freeways, freeway components, two-lane rural highways, multi-lane highways. Laboratories emphasize the use of spreadsheets in data analysis and the use of computer packages for capacity and level of service analysis. **Also listed under CE 805.**

**TR 702 Traffic Engineering II**  
2½:2½:0:3

Second course in a two-semester sequence covering the basis of traffic engineering. Traffic control operations, and management. Characteristics of signs, signals, and markings. The "Manual on Uniform Traffic Control Devices" and its use. Intersection control. Signal systems and coordination. Pretimed and actuated control. Design of street hardware. Traffic flow regulations and their implementation. Intersection and arterial analysis. *Prerequisite: TR 701 or equivalent.* **Also listed under CE 807**

**TR 703 Computer Applications and Analytic Techniques in Traffic and Transportation**  
2½:0:0:3

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. Sensitivity analysis. Cost-utility analysis. Surveys and errors in surveys. Transportation packages including NETSIM, TRANSYT, TRAF, and Assignment packages. *Prerequisites: TR 702.* **Also listed under CE835.**

**TR 704 IVHS**  
2½:0:0:3

Intelligent Vehicle Highway Systems (IVHS) are a topic of much discussion, and a major thrust in Federal legislation. This course is designed to acquaint the student with the terminology, issues, and state of the art in IVHS activities and to cause discussions on the implications of IVHS activities.

**TR 710 Design of Traffic Facilities**  
2½:0:0:3

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 CE 821.**

**TR 722 Fundamentals of Pavement Design**  
2½:0:0:3

Pavement types, design factors, traffic load analysis, pavement materials, stresses in flexible and rigid pavements, economic factors, pavement strategies and design of flexible and rigid pavements. **Also listed as CE 796.**

**TR 723 Flexible and Rigid Pavements**  
2½:0:0:3

Advanced course in the design and evaluation of flexible and rigid pavements for highways and airports: System approach, stochastic process, pavement condition and performance, advanced traffic load analysis, subgrade investigation, properties of subbase, base, asphaltic, and concrete courses, climatic and environmental effects, design strategies, design of highways and airport pavements and pavement evaluation. **Also listed under CE 797**

**TR 724 Pavement Materials Laboratory**  
1:3:0:3

Practical course on testing of pavement materials: Physical and indicative tests, soil classifications, CBR test, tests on asphalts, Marshall test, Hveem tests, Fatigue testing, application of results in a design problem. *Prerequisite: TR722.* **Also listed under CE 814.**

**TR 725 Advanced Pavement Technologies**  
2½:0:0:3

Advanced course on evolution and innovative recent paving technologies: AASHO road test, pavement management system, concrete block pavements,

## TRANSPORTATION

pavement recycling, geotextiles in pavements, pavement rehabilitations, bituminous materials, modern materials. *Prerequisites: TR723, TR724. Also listed under CE 814.*

### **TR 750 Transportation Economics and Finance** *2 1/2:0:0:3*

Basic principles of present worth, single payment and uniform series, sinking funds, annualized costs. Differences in the public and private sectors of transportation: profit, depreciation, return on capital. Benefit-cost analysis. Rate of return. Bond issues. Formulation and use of unit costs in highways, transit, and other modes. History of financing of road systems, transit, and trucking. Privatization. **Also listed under CE 812.**

### **TR 759 Transportation Policy** *2 1/2:0:0:3*

Analysis of the major policies, regulations, and controls established or imposed by government at all levels-federal, state, local-which currently impact on the transportation industry. (All modes considered). Case studies used extensively. **Also listed under CE843.**

### **TR 760 Management of Transit Maintenance and Operations** *2 1/2:0:0:3*

Management of functional transit systems, including design and monitoring of maintenance functions to provide viable operating fleets and right-of-way, and management of daily operations, including scheduling, run-cutting, dispatching, and street management. **Also listed under CE844.**

### **TR 860-861 Selected Topics in Transportation I,II** *each 2 1/2:0:0:3*

Periodic presentation of topical materials of current interest. Possible topics presented are: site development and site impact; decision-making in transportation; computer packages in transportation; transportation systems safety. *Prerequisite: academic adviser's approval. Also listed under CE845-846.*

### **TR 865 Traffic Safety Engineering** *2 1/2:0:0:3*

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 hazards and hazardous conditions in every stage of the highway system activity cycle, including planning, engineering, design, operation, maintenance. **Also listed under CE847.**

### **TR 901-902 Readings in Transportation I, II** *2 1/2:0:0:3*

Special problems in transportation under the direct supervision of faculty members. *Prerequisite: academic advisers' approval. Also listed under CE903-904.*

### **TR 951-952 Transportation Seminar I, II**

Relevant topics in transportation by guest speakers. Presentations and discussions of on-going research by course participants and faculty. Required of all full-time degree students in the program. *Prerequisite: academic advisers' approval. Also listed under CE954-955.*

### **TR 962 Master's Project in Transportation Planning and Engineering** *each 3 units*

An independent project leading to a comprehensive report demonstrating professional competence. Reports must be orally defended and be submitted in acceptable (unbound) written form. *Prerequisites: degree status and academic advisers' approval. Also listed under CE957.*

### **TR 963 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 acceptable (unbound) written form.

*Prerequisites: degree status and academic advisers' approval. Also listed under CE958.*

### **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 (unbounded) written form. *Prerequisites: degree status and academic adviser's approval. Also listed under CE959.*

### **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. Also listed under CE960.*

### **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. Also listed under CE999.*

## FACULTY

**Ilan Juran**, Professor of Civil Engineering, Head of the Department of Civil and Environmental Engineering, B.Sc. Technion, Israel; PhD, D.Sc. Paris XI, Ecole Nationale des Ponts et Chaussees.

*Geotechnical engineering, soil improvement technologies, geosynthesis engineering, in-situ soil testing*

**ADJUNCT FACULTY**

**John C. Falcocchio, P.E.**, Professor of Transportation; Program Coordinator, Transportation  
 B.C.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*

**Dimitrios G. Goulias**, Assistant Professor of Civil Engineering  
 M.S.C. E., Università Degli Study Della Calabria, Italy; M.S.C.E., University of Michigan; Ph.D., University of Texas, Austin  
*Highway engineering; pavement design performance evaluation; pavement management; non-destructive testing.*

**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.**, Research Professor of Transportation  
 B.S.C.E., Illinois Institute of Technology; Certificate in Highway Traffic Engineering, Yale University  
*Traffic operations, traffic engineering and capacity, highway engineering, transportation policy*

**William R. McShane, P.E.**, Professor of Industrial and Systems 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*

**Roger P. Roess**, Professor of Transportation Engineering and Dean of Engineering, Vice President for Academic Affairs  
 B.S.,M.S.,PhD.,Polytechnic Institute of Brooklyn  
*Traffic capacity and design; traffic engineering; public transportation; transportation economics*

**Elena S. Prassas**, Instructor in Transportation; Deputy Program Coordinator, Transportation Program  
 B.A., State University of New York, Oneonta; M.S. Polytechnic Institute of New York  
*Traffic engineering; transit and economics; AI applications; software systems for transportation applications.*

**Jose M. Ulerio**, EIT, Instructor in Transportation  
 B.S.,M.S.,Polytechnic Institute of New York  
*Highway engineering; highway capacity; transportation assignment; transportation demand estimation; CAD and CAE applications.*

**Paul Cohen**, Adjunct Assistant Professor  
 B.A., City College of New York; M.S., University of Illinois.

**Philip A. Habib, P.E.**, Adjunct Professor  
 B.E., City College of New York; M.S., Ph.D., Polytechnic Institute of Brooklyn.

**Michael Hurodniceanu, P.E.**, Adjunct Professor  
 B.S., Technion Israel Institute of Technology; M.S., Columbia University; Ph.D., Polytechnic Institute of New York.

**Richard Newhouse, P.E.**, Lecturer  
 B.S., M.S. Polytechnic University

**Gennaro E. Sansone**, Lecturer  
 B.S.E.E., Kansas State University; M.B.A., Iona College.

**David Sampson**, Lecturer  
 B.A., Colby College; M.S., Harvard University

**Raymond Schaeffer**, Lecturer  
 B.S.(CE), M.S.(Transportation), Swiss Federal Institute of Technology.

# PART III

## SPECIAL PROGRAMS



# ACADEMIC HONOR STUDENTS

Polytechnic provides many forms of recognition and encouragement for students who demonstrate outstanding academic achievement. While more detailed descriptions of some of these honors opportunities are found elsewhere in this catalog, this section summarizes them in one place to emphasize Polytechnic's commitment to the nurturing of academic excellence.

Students can be recognized for academic excellence from the moment they arrive at Polytechnic until the time when they leave at graduation. Based on test scores, incoming freshmen can receive advance placement credit for some of their college courses, making it possible for them to make faster progress toward their degrees, and to take additional elective courses. Upon graduation, students having the highest academic records are recognized by honors degrees and special prizes.

Each semester, the names of students with high grade-point-averages are publicly recognized on the Dean's List. Students who have high academic achievements at the end of their junior years are also publicly recognized. Those Senior Honor Students are given more flexibility in choosing specialized electives and graduate courses during their senior year. The annual award ceremony also includes presentation of many prizes to students for high achievement in specific programs and academic competitions.

Some departments offer Honors Programs in which students gain accelerated progress toward simultaneous BS and MS degrees based on advanced placement, summer courses, and modified degree requirements.

Academically outstanding students have opportunities to participate in undergraduate research by working with faculty and graduate students on projects that may be funded by industrial organizations or government agencies like the National Science Foundation.

The top senior students in each discipline may be elected to the local chapters of their respective national honor societies. Activities of those honor societies include special colloquia on research topics, and providing tutoring service to other students at Polytechnic and to students in local high schools.

# COOPERATIVE EDUCATION PROGRAM

The Cooperative Education (Co-op) Program provides students with practical work experience in industry, government and public service agencies. This experience contributes to the student's career decision making ability, motivates academic performance and provides a competitive advantage in the job market. Students can also earn a substantial salary while employed in a Co-op position.

The Co-op program alternates semesters of classroom study with semester of work. A student may Co-op for up to five work periods (semesters) and may require a five year undergraduate program depending on the number of semesters spent working. Each Co-op student designs a Co-op work-study program with the help of their academic adviser. Eligible students can begin co-oping in their sophomore year. Seniors and graduate students are not eligible for the Co-op program.

Students accepted into the program start interviewing with participating Co-op companies during the semester prior to the first scheduled work period. Companies select students based on their employment needs and the process is competitive. Co-op students are given work directly related to their career goals and level of academic experience. Co-op students are paid salaries based on their experience and academic level.

The Cooperative Education Program is a non-credit, optional program. Students participating in the program for at least two Co-op field experiences receive Co-op certificates upon graduation. Students who have a Co-op position and are not attending classes do not pay tuition during the work period; however there is a small registration fee for Co-op experience. (Fee is waived for summer Coop.)

## ELIGIBILITY

### Before applying for the initial Co-op work assignment, students must:

- Complete two full-time semesters at Polytechnic.
- Achieve and maintain a 2.5 grade point average.
- Have sophomore status (28+ credits) with no course deficiencies.
- Complete at least one technical course in the major as determined by their academic department.
- Successfully complete CP 101 (Career Development Seminar).
- Obtain adviser approval for program participation (work-study plan signed by adviser).

### Transfer Students are required to:

- Complete one semester of full-time study at Polytechnic University before beginning their first work period.
- Successfully complete CP 101 (Career Development Seminar).
- Achieve a 2.5 grade point average at Polytechnic University.
- Obtain departmental approval for program participation (work-study plan signed by adviser).

## CO-OP SEMINARS

The Co-op Pre-Employment Seminar (CP 101) prepares students for entry into professional environments and is a prerequisite to participation in the work experience sequence.

CP 101 examines methods of discovering fields which are most fulfilling. Topics include self assessment, techniques of resume writing, interviewing, making contact with prospective employers, communication in the workplace, ethics, and other topics that foster students' successful adjustment in the workplace. Students also have an opportunity to meet co-op employers and co-op students who have been out working.

Students entering work assignments after the sophomore year can complete up to four field experience courses, CP 201 through CP 302. Types, complexities and challenges of field assignments vary depending on the student's 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**

**CP 101 Cooperative Education Seminar I** 1:0:NC

**CP 201 First Co-op Field Assignment** 0:0:NC  
*Prerequisite: CP 101, CP 102 or departmental approval*

**CP 201 First Co-op Field Assignment** 0:0:NC  
*Prerequisite: CP 101, CP 102 or departmental approval*

**CP 202 Second Co-op Field Assignment** 0:0:NC  
*Prerequisite: CP 201*

**CP 301 Third Co-op Field Assignment** 0:0:NC  
*Prerequisite: CP 202*

**CP 302 Fourth Co-op Field Assignment** 0:0:NC  
*Prerequisite: CP 301*

**CP 401 Fifth Co-op Field Assignment** 0:0:NC

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**

**Jeanette Grill**, Director, Career Services and Cooperative Education  
 B.A., Molloy College;  
 M.S., Polytechnic University

**Glennis Daniels-Bacchus**, Assistant Director, Career Services and Cooperative Education  
 B.A., Fordham University

**Sari Goren**, Assistant Director, Career Services and Cooperative Education, Long Island Campus  
 B.S., M.S., Brooklyn College;  
 M.S., Hofstra University

**Joy Sprecher**, Coordinator of Job Development Program  
 B.A. Brooklyn College  
 M.S. University of Nebraska

# HEOP

The Higher Education Opportunity Program (HEOP) is a special program designed to provide broad and varied educational experiences to capable students who, due to academic underpreparation and limited financial resources, might otherwise not have an opportunity to attend college. HEOP assists its students by providing academic support services, counseling and financial aid to enable them to successfully complete their programs of study at Polytechnic. A goal of the University and of HEOP is to graduate minority and non-traditional students from professional career areas where these students have historically been underrepresented.

## ADMISSION

To qualify for the program, applicants must be residents of New York State and both educationally and economically disadvantaged. To qualify as educationally disadvantaged, applicants must generally not be admissible to Polytechnic based on regular admissions academic criteria. However, there must be an indication of potential to succeed in college. Economic disadvantage is determined on the basis of income guidelines issued by the State Education Department. These guidelines may change periodically. For further information, please contact the HEOP office.

The pool of potential HEOP students comes from the public and private high schools in the five boroughs of New York City. In 1992-93, 170 applications were received for HEOP admission at Polytechnic. Seventy-three of these students were interviewed, 20 were accepted and 20 enrolled.

A HEOP student is accepted directly into his or her major department. However, a student who is undecided as to major is registered as a HEOP major and can transfer to a department at the end of the freshman year. HEOP transfer applicants must be admissible to the academic department

in which they intend to major, and must have a signed HEOP Transfer Application Form on file.

For HEOP applicants, who have not developed their academic skills to their potential, SAT scores may not reflect the chance for success at Polytechnic. Therefore, a personal interview with each applicant is an essential part of the HEOP admission process. In this way, the more subjective criteria for success can be explored, such as:

- understanding of the major chosen
- commitment to a four-year degree
- realistic financial planning for college
- acceptance of the need for tutoring, counseling, remediation and summer course work
- realistic assessment of an individual's academic deficiencies and strengths
- involvement of the student's family in career plans

In order to transfer into HEOP at Polytechnic, students must have been in an opportunity program (HEOP, EOP, SEEK, etc.) at their previous institution. Each applicant must also complete the regular transfer application. Transfer applicants are reviewed based on individual circumstances. The reasons for transfer, college transcript(s), and recommendations from counselors or professors are reviewed by the HEOP Director, and a recommendation is sent to the academic department to which the applicant is seeking admission.

## ACADEMIC SUPPORT SERVICES

These services include:

- A pre-freshman summer program, including courses in mathematics, chemistry, and study skills. In addition, group and individual counseling sessions are scheduled to assist students in making the transition to college.

- Study skills courses during the fall and spring semesters.
- Tutoring program.
- Individualized study skills sessions.

## COUNSELING

In order to meet the needs of the student, the program provides counseling in the following areas: personal, socioenvironmental, academic, financial, and career.

## FINANCIAL AID

Full financial aid is provided for the pre-freshman summer program and for the regular academic year. Students are required to supplement their financial aid packages with minimal federal loans.

## APPLICATION PROCEDURES

Students apply for HEOP by completing the regular application for admission. They should indicate on the application their interest in being considered for HEOP. It is very important that students complete the Financial Aid Form (FAF) early to enable the University to determine their economic eligibility for HEOP. Students who meet the educational and economic qualifications are then required to have a personal interview.

**COURSES**

**CM 000 Pre-College Chemistry**

9:0:NC

Mole concept and stoichiometry; gaseous molecular behavior and gas law; equilibrium and Le Chatelier's principle.

**HE 000 Study Skills**

2:0:NC

A workshop which includes: a close examination of a student's expectations and survival skills; note taking and text book use; re-evaluation of goals and career objectives.

**MA 000 Pre-College Math**

9:0:NC

Review of trigonometry, quadratic and absolute value questions and inequalities, limits and differentiation of both algebraic and trigonometric functions.

**PROFESSIONAL  
STAFF**

**Constance Costa**, Director, HEOP  
B.S., Wagner College; M.S. College of Staten Island

**Teresina W. F. Tam**, Assistant Director, HEOP  
B.A., Concordia University; M.S., Wilfrid Laurier University

**Jorge L. Yau**, Counselor, HEOP  
B.S., Polytechnic University

# MILITARY SCIENCE

The Department of Military Science administers the Reserve Officer Training Corps program and provides college-trained officers for the United States Army Reserve. Best explained in the words of Dr. Lee S. Dreyfus: "The Reserved 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 as officers in the United States Army while earning their college degrees. As commissioned officers they serve on active duty or as citizen soldiers in the Reserve Forces upon graduation. ROTC graduates provide critical leadership to the U.S. Army, government and industry.

## 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 (except scholarship contracted students). Subjects cover the following areas: first aid, national defense, drill and

ceremonies, physical conditioning, map reading, survival techniques, 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.

All students in the Basic Course are organized into the cadet student battalion. Some Saturday or Weekend training is included in the coursework. Uniforms may be issued to Basic Course students who are active in the 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. These subjects are taught in the classroom, in laboratories and during field training exercises. 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 field environment.

All cadets in the Advanced Course receive uniforms, pay, and necessary military science textbooks for Advanced Camp. Contracted U.S. citizens also receive a living allowance 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 may possibly obtain a commission once they obtain U.S. citizenship.
2. Qualify for appointment as a second lieutenant prior to reaching 30 years of age.

3. Be approved by the Professor of Military Science.
4. Successfully pass a prescribed medical examination.
5. Successfully pass an educational level examination and a leadership assessment program.
6. Have successfully completed the two-year Basic Course or its equivalent. Minimum Basic Course requirements consist of successful completion MS 101, 102, 201 and 202.
7. Sign a contract with the U.S. Army agreeing to pursue the standards required for Commissioning.

### 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, during the summer. Students may then enroll in the Advanced Course in their last two years, provided they meet enrollment requirements.

### OBLIGATIONS

Cadets must successfully meet ROTC standards. 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, approximately two thirds of those students requesting active duty are 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 would be their choice. 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 two-, three- and four-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 two- and three-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 fee, plus a living allowance each year the scholarship is in effect.

### REQUIREMENTS FOR COMMISSIONING

1. Completion of the Basic Course or Equivalent
2. Completion of the Advanced Course
  - a. MS 301, 302, 303 (or approved history course determined by the Department Head), 304.
  - b. MS 401, 402, 403.
  - c. Advanced Camp.
  - d. Meet Army Physical Fitness Standards.

### CREDITS TOWARD POLYTECHNIC DEGREES

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.

A student may substitute up to six credits from the four two-credit courses (MS 301, 303, 401 or 403) for free/technical electives as authorized by the individual departments.

### PROFESSIONAL ACTIVITIES

The military science program offers a variety of social and professional activities:

**Scabbard and Blade** is the 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 drill and ceremonies, military training and in organizing ceremonial color-guards.

**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, orienteering and tactics.

### HOW TO ENROLL IN MILITARY SCIENCE (ROTC)

Students interested in the two-year program should contact the department early in their sophomore year for application deadlines. If students have any questions concerning the military science program, they should telephone (718) 260-3150. Students should visit the Department of Military Science during the registration period so that the desired course can be integrated with normal registration procedures.

### BASIC COURSE

#### 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. Introduction to physical fitness training and planning, land navigation, and basic rifle marksmanship. The course also includes several lab periods or field trips which allow for application of skills taught. Extra credit field training exercises are available.

#### MS 102 Introduction to Military Science II 1:1:0

Development of self-confidence in students, as well as skill necessary to navigate using a map and compass, and continued development of physical fitness. First aid measures consisting of basic lifesaving steps are included in this course. Extra credit field training exercises are available: *Prerequisite: MS 101 or permission of department head.*

#### MS 201 Military Skills I 1:1:0

Basic skills associated with small unit leaders; tactics and communications skills; theoretical and practical applications of military marksmanship; basic marksmanship including the firing of the M16 rifle during an off campus field trip. Oral and written communication techniques and skills required of successful leaders. Students are required to participate in practical exercises which apply all military skills from previous classes and several labs. Extra credit field training exercises are available. *Prerequisite: MS 101 and 102 or permission of department head.*

#### 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 a individual level. Principles and traits of leadership, human behavior and psychology, command, discipline, decision making, the leadership assessment program, and how to prepare to conduct performance-oriented training. The

## MILITARY SCIENCE

course also includes a field trip which applies all military skills and several laboratories previously taught. Extra credit field training exercises are available. *Prerequisite: MS 201 or permission of the department head.*

### ADVANCED COURSE

**MS 301 Leadership and Management Techniques** 2:0:2 or *nc as arranged*

Theory and techniques used by successful leaders and managers are taught. Within the management portion, the interpersonal skills needed to lead and work with others are developed and practiced by individuals in small group practical exercises. *Prerequisite: Completion of the Basic Course or its equivalent and permission of the department head.*

**MS 302 Leadership Skills I** 2:2:0

Soldier skills, physical capabilities and high motivational attitudes required to meet demands of today's modern army officers. Cadets receive hands-on instruction 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 reliance. A six-week leadership camp follows this course during the summer months. Students are required to attend various field training exercises to reinforce classroom training and to meet standards in land navigation and physical training. *Prerequisite: enrollment in MS 301.*

**MS 303 American Military History** 2:1:2 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. This course includes a one-day trip to a local battlesite. *Prerequisite: none.*

**MS 304 Leadership Skills II** 2:2:0

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 prior to Advanced Camp. Students must meet standards in required military skills to attend Advanced Camp. *Prerequisite: MS 302.*

**Advanced Summer Camp** *nc*

All candidates for commission through military science are required to successfully complete advanced camp, held at Fort Bragg, North Carolina. Stresses leadership and command responsibility, implemented by a command rotation system that places each student in varying positions of authority during the course of the normal military training and field operations. 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: MS 301, 302 and 304.*

**MS 401 Military Law, Ethics and Professionalism** 2:0:2 or *nc as arranged*

The military justice system to include jurisdiction, military crimes and rights of individuals, as well as the non-judicial and judicial options available to maintain discipline in the Army are examined. Ethics and professionalism in the military environment are discussed. Ethical reasoning and decision-making processes are developed and utilized in relation to case studies. *Prerequisite: Permission of the department head.*

**MS 402 Applied Leadership** 2:2:0

Leadership skills necessary for cadet officers to function in areas such as formal classroom instruction, planning and conducting field training exercises, and administration of the cadet battalion are stressed. The course is structured to permit formal instruction followed by a laboratory each week for practical application. Students are required to attend various field training exercises to reinforce classroom training. *Prerequisite: MS IV cadet standing.*

**MS 403 Pre-Commissioning Seminar** 2:2:2 or *nc as arranged*

Prepares senior cadets for commissioning as second lieutenants in the U.S. Army. Studies include 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, permission of the department head.*

# PHYSICAL EDUCATION AND ATHLETICS

The major goal of the Physical Education program is to offer a wide range of physical activities for the benefit and enjoyment of the student body. With guidance from their instructors, students can develop skill and success in a chosen activity while having fun and experiencing an optimum condition of physical fitness in terms of strength, agility, endurance and tension relaxation.

## INTERCOLLEGIATE ATHLETICS

All full-time undergraduate students who are in good academic standing are eligible for team membership, and are encouraged to participate and win their varsity letter.

Polytechnic is a member of the N.C.A.A., E.C.A.C., and the I.A.C. and fields varsity teams in men's basketball, baseball, cross country, judo, lacrosse, soccer, tennis, wrestling, women's cross country, judo, tennis and volleyball.

## 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, wrestling and other sports that may be offered. Winners of the intramural basketball and volleyball tournaments compete in the tri-state area college intramural championships.

## PHYSICAL EDUCATION COURSES

The University and all of its degree granting departments strongly recommend and encourage all undergraduates to register for a minimum of two semesters of Physical Education.

Courses may be selected in any sequence. A student may elect to take the same course for more than one semester.

### PE 101 Racquetball 0:2:0

Fundamentals for beginners, leading to interclass tournament play for novice and advanced players.

### PE 102 Weight Training 0:2:0

Individualized weight training program developed on Nautilus and/or Universal weight training equipment. The Nautilus machines allow for rotary movement; they exercise specific muscles throughout the student's full range of motion.

### PE 103 Team Sports 0:2:0

Basic skills, conditioning and strategy needed while participating in team and carry over sports, volleyball, basketball and badminton.

### PE 105 Martial Art Karate And Judo 0:2:0

Fundamental principles and basic karate techniques including katas and light sparring, plus the principles of sport judo. Includes throwing techniques, matwork, and rules leading to tournament play.

## FACULTY

**Joseph Martini**, Director of Physical Education and Athletics; B.S., Long Island University; M.S., Brooklyn College

**Maureen Braziel**, Associate Director of Athletics; B.A., Hunter College; M.S. Hunter College

**Louis Zinser**, Assistant Director of Athletics; B.S., University of Baltimore; M.S., Hofstra University

## COACHING STAFF: VARSITY TEAMS

**Paul Oberjosh**, Lacrosse Coach

**Laddy Baldwin**, Basketball Coach

**Henry Boyton**, Assistant Baseball Coach

**Maureen Braziel**, Men's & Women's Judo Coach, Women's Volleyball Coach

**Tom Francavilla**, Baseball Coach

**Rich Lucian**, Men's & Women's Cross Country Coach

**Joseph Martini**, Tennis Coach, Men's & Women's

**Niek Russo**, Assistant Cross Country Coach

**Art Williams**, Assistant Basketball Coach

**Louis Zinser**, Soccer Coach

# THE YES CENTER

The Mission of Polytechnic's Center for Youth in Engineering and Science (YES) is to promote activities which sensitize high school students to career opportunities in engineering and science, nurture their interest, develop their scientific curiosity, and encourage them to pursue appropriate study. The YES Center addresses these needs through a variety of high school outreach programs designed to interest pre-college students in technological careers based upon an understanding of and fascination with technology. Special attention is paid to attracting the interest of students from populations traditionally under-represented in engineering and science careers, specifically women and minorities. The Center sponsors a number of outreach programs which are briefly described in this brochure, including: *The Summer Research Institute, the College Preview Program, university tours, special seminars and events, tutoring programs, and opportunities for high school teachers.* Students may enroll in a YES Center program at either the Brooklyn or Long Island campus.

## RESEARCH

The Summer Research Institute is a 6-week full-time summer effort focused on the conduct of an independent research project with a faculty member. Students are paid a stipend for this period of time. The student will be part of a research effort, either individually or as part of a group, focused on a problem formulated by the student in conjunction with his/her faculty mentor. If the student so desires, the effort may be geared towards submission of results to the Westinghouse Science Talent Search and/or other prestigious science competitions.

## SEMINARS

An instructional component specially designed to supplement the research experiences of student participants is an integral part of the Institute program. Sessions will be devoted to drafting preliminary essays, learning the appropriate format for a science paper, compiling the Data Profile for a Westinghouse Talent Search submission, and presenting research results and sharing experiences. Several seminars will involve outside speakers and role models from the University and from industry. Appropriate field trips will be arranged to enhance the students' research experiences.

## DURATION OF THE PROGRAM

The Summer Research Institute is itself a six-week full-time effort. During this six-week summer period, students are expected to make a full-time commitment to the program, for which they are paid a stipend. Seminars will be held regularly throughout the program on a scheduled basis, and all participants are required to attend these.

Students will also be expected to attend any preparatory seminars needed to allow them to effectively conduct their research during the 6-week summer session. Such preparatory sessions are arranged for the students' convenience during after-school hours. Students wishing to continue their research beyond the summer period may make individual arrangements to do so.

The Summer Institute also includes the opportunity to spend several days in residence at Polytechnic's Long Island Center in Farmingdale, New York. Designed to provide a taste of college life, this workshop will have a full schedule of supervised activities, including lectures, demonstrations, discussions, tours, and recreational activities. Room and board in Polytechnic's on-campus dormitories will be provided.

## QUALIFICATIONS

Admission to the program is competitive, and will be determined by the student's scholastic ability, scientific/technology background and interest, recommendations from high school teachers, principals, or counselors, and motivation. Students should be high-school juniors who will begin their senior year after completing the Institute program, although applications from outstanding sophomores will also be considered. Applications should be available at your high school, or can be requested from the YES Center (718-260-3033).

## EXPENSES

Students, depending upon individual schedules, will need lunch money and transportation to and from the University. The University will provide all transportation for field trips and tours, and provides room and board for the residential portion of the program.

## COLLEGE PREVIEW PROGRAM

Introductory college courses at Polytechnic are offered to outstanding high school students. Interested students must complete an application and obtain a recommendation from their guidance counselor or principal. Polytechnic waives regular tuition and charges a \$50 per course registration fee. Students earn college credits for satisfactorily completed course work, and a transcript is produced. Courses available include beginning courses in college mathematics, computer science, physics, chemistry and selected courses in the humanities and social sciences. Application for Fall courses must be submitted during the first week of

September; for Spring courses, applications are required in mid-January. Applications are available at your high school, or from the YES Center at the number indicated herein.

### **UNIVERSITY TOURS**

The University regularly sponsors tours of its laboratories and facilities. Included also are demonstrations, lectures on careers in engineering and science, and presentations on college planning and financial aid. Any interested high school can arrange for such a tour by calling the YES Center.

### **PROGRAMS FOR HIGH SCHOOL STAFF MEMBERS**

Speakers, workshop facilitators, and specialists may be obtained from the University to conduct special staff development/training workshops for high school teachers. Polytechnic also offers a special 50% tuition discount for full-time teachers taking courses at Polytechnic. Documentation from the home school is required.

### **SPECIAL SEMINAR PROGRAMS**

Polytechnic sponsors seminars, conferences, and lectures in science, technology, engineering, social science, mathematics, and computer science. High school students and faculty members are invited to participate. Several programs each year are specifically aimed at high school students and faculty, and information is distributed to high schools concerning these. Any high school interested in a seminar on a particular topic may call the YES Center to determine if we can accommodate the request.

### **TUTORIALS**

Students from Polytechnic's computer science and electrical engineering majors, and from several student organizations, are available on a limited basis to provide tutoring services. High schools interested in participating should call the YES Center.

### **SCHOLARSHIPS**

Students from high schools participating in Center-sponsored activities are eligible for special PROMISE Scholarships earmarked for such students should they choose to attend Polytechnic University.



**Clarence Nelson**, Program Director, B.S., P.E., Polytechnic Institute

**George Fischer**, Professor Emeritus, Faculty Coordinator

# PART IV

- **The Corporation**
- **The Administration**
- **The Faculty**



# THE CORPORATION

## Chairman

Joseph J. Jacobs, *Chairman of the Board, Jacobs Engineering Group Inc.*

## Vice Chairman

Clifford H. Goldsmith, *Principal, The Prendel Co.*

## Secretary

Henry J. Singer, *Vice President, General Electric Company*

## Trustees

Franklin Blecher, *Retired Executive Director, Technical Info. Systems Division, AT&T Bell Laboratories*

Gioia Marconi Braga, *Council Chairperson, Marconi International Fellowship*

Robert P. Brown, *Former Chairman, Poloron Products, Inc.*

George Bugliarello, *President, Polytechnic University*

Ralph W. Casazzone, *President, First National Oil Brokers*

Michael R. Corey, *Treasurer, Morgan Guaranty Trust Company*

Donald M. Cox, *Retired Director, Exxon Corp.*

Anthony S. D'Amato, *Chairman and CEO, Borden, Inc.*

Robert D. Dalziel, *Retired Vice President, AT&T Global Networks*

David Dibner, *Former Chairman, Burndy Corp.*

Herman Fialkov, *Partner, PolyVentures*

William L. Friend, *Executive Vice President, Bechtel Group, Inc.*

Fred Heinzelman, Jr., *President, Fred Heinzelman & Sons*

Linda Jacobs, *President, Middle East Technology Assistance (META)*

Hans Mark, *McKetta Energy Chair, The University of Texas at Austin*

Arthur C. Martinez, *Chairman & CEO, Sears Merchandise Group, Sears Roebuck & Co.*

John S. Mayo, *President, AT&T Bell Laboratories*

R. William Murray, *President & Chief Operating Officer, Philip Morris Companies, Inc.*

Robert J. Myers, *President and Chief Operating Officer, Grumman Corp.*

Stewart G. Nagler, *Senior Executive Vice President & Chief Financial Officer, Metropolitan Life Insurance Co.*

Kenneth Olshan, *Chairman, Wells, Rich Greene, Inc.*

John G. Puente, *Chairman and CEO, Orion Network Systems*

Clarence F. Silleck, *Retired Vice President, CJ Osborn Chemicals, Inc.*

Casimir Skrzypczak, *President, Science & Technology, Inc., NYNEX*

Paul Soros, *President, Soros Associates International, Inc.*

Jerome Swartz, *Chairman and CEO, Symbol Technologies, Inc.*

Steven J. Wallach, *Vice President, Convex Computer Corp.*

Harry C. Wechsler, *President, Farboil Co.*

## Honorary Trustees

Gregory Halpern, *Chairman of the Board, Universal High Technologies*

J. Erik Jonsson, *Retired Chairman, Texas Instruments*

Koji Kobayashi, *Chairman Emeritus and Representative Director, NEC Corp.*

## Trustees Emeriti

William E. Leistner, *Chairman of the Board and Chief Executive Officer, Fairmount Chemical Co.*

William F. May, *President, Statue of Liberty/Ellis Island Foundation, Inc.*

Louis N. Rowley, Jr., *Consulting Editor, Power & Electric World, McGraw-Hill Publications*

Ernst Weber, *President Emeritus, Polytechnic University*

George L. Wilcox, *Retired Director and Vice Chairman, Westinghouse Electric Corp.*

## Advisory Trustees

Donald M. Alstadt, *Chairman of the Board, Lord Corp.*

Henry Bachman, *Vice President Engineering, Hazeltine Corporation*

Willard R. Bischoff, *Retired Vice Chairman, Technology, Grumman Corp.*

Vincent A. Calarco, *President and Chief Executive Officer, Crompton & Knowles Corp.*

Joseph M. Guglielmi, *Chairman and Chief Executive Officer, Taligent Inc.*

Paul Hallingby, Jr., *Senior Managing Director, Bear, Stearns & Co. Inc.*

Eugene Kleiner, *Retired Partner, Kleiner Perkins Caulfield & Byers*

Richard Laster, *President and Chief Executive Officer, DNA Plant Technology Corp.*

Louis H. Pighi, *Retired President, Fairchild Weston Systems, Inc.*

Leonard F.C. Reichle, *President & Chief Executive Officer, Reichle Development Corp.*

Charles Strang, *Chairman, Outboard Marine Corp.*

Jerry M. Sudarsky, *Vice Chairman, Jacobs Engineering Group, Inc.*

# THE ADMINISTRATION

## ADMINISTRATIVE OFFICERS

George Bugliarello, Sc.D., *President*  
Ivan T. Frisch, Ph.D., *Provost*  
Robert J. Maciag, M.S., *Senior Vice President, Finance and Administration*  
Helen T. Lowe, M.B.A., *Senior Vice President, Institutional Advancement*  
Richard Mandelbaum, Ph.D., *Vice President, Information Technology & Services*  
Roger P. Roess, Ph.D., *Vice President, Academic Affairs/Dean of Engineering*  
Richard S. Thorsen, Ph.D., *Vice President, Research and Advanced Programs*

## ACADEMIC ADMINISTRATION

Ivan T. Frisch, Ph.D., *Provost*  
Roger P. Roess, Ph.D., *Vice President, Academic Affairs/Dean of Engineering*  
Kathleen V. MacDonald, Ed.D., *Dean, Westchester Graduate Center*  
William R. McShane, Ph.D., *Dean, Long Island Campus*  
Allan S. Myerson, Ph.D., *Dean, School of Chemical and Materials Science*  
Leonard G. Shaw, Ph.D., *Dean, School of Electrical Engineering and Computer Science*

## Career Services

Jeanette Grill, M.S., *Director*  
Giannis Daniels-Bacchus, B.A., *Assistant Director, Brooklyn Campus*  
Sari Goren, M.S., *Assistant Director, Long Island Campus*  
Joy Sprecher, M.S., *Coordinator, Job Development Program*

## Special Services

Haang Fung, M.S., *Director*  
Yona Jean-Pierre, B.A., *Assistant Director, Brooklyn Campus*  
Lenore Waldman, M.S., *Assistant Director, Long Island Campus*  
Dolores Bursky, M.S., *Counselor, Long Island Campus*  
Janie Groff, M.A., *Counselor, Brooklyn Campus*  
Marc Schnall, M.S.W., *Counselor, Brooklyn Campus*  
Waffaa Hanna, B.S., *Coordinator of Tutorial Services, Long Island Campus*  
Heather Shields, M.S., *Coordinator of Tutorial Services, Brooklyn Campus*

## Higher Education Opportunity Program (HEOP)

Constance Costa, M.S., *Director*  
Teresina Tam, M.S., *Assistant Director*  
Jorge Yau, B.S., *Counselor*

## Student Life

Jeffrey A. Kessler, M.S., *Assistant Vice President/Dean of Students*  
Cheryl A. McNear, B.S., *Assistant Dean of Students*  
Carol A. Parmentier, M.F.A., M.S., *Assistant Dean of Students*  
Donald N. Ivanoff, B.F.A., *Coordinator, Student Activities & Housing, Brooklyn Campus*  
Indira Chandra, M.S., *International Student Advisor*  
Randall J. Pawlowski, M.S., *Director of Student Life, Long Island Campus*

## RESEARCH AND ADVANCED PROGRAMS

Richard S. Thorsen, Ph.D., *Vice President, Research & Advanced Programs*  
Gayla V. Merryman, B.S., *Director, Continuing Professional Education & Corporate Training*  
Vacant, *Director, Human Resources*  
Joseph Scelso, B.B.A., *Director, Contracts & Grants*

## INFORMATION TECHNOLOGY AND SERVICES

Richard Mandelbaum, Ph.D., *Vice President, Information Technology & Services*  
Donald Hockney, Ph.D., *Vice Provost, Information Technology*  
Antonio Monteiro, B.S., *Director, Administrative Applications*  
Richard Sweeney, M.L.S., M.A., *Vice Provost/Dean of Libraries & Information Services*

## Libraries

Richard Sweeney, M.L.S., M.A., *Vice Provost/Dean of Libraries & Information Services*  
James Jarman, M.L.S., M.S., *Assistant Dean, Libraries & Information Services*  
Aline Locascio, M.L.S., *Assistant Dean, Libraries & Information Services*  
Lorraine Schein, M.L.S., M.S., *Manager, Long Island Campus Library, Acquisitions*  
Mary Duffy, M.L.S., *Librarian*  
Lilliana Middleton, M.L.S., *Librarian*  
Laura Navarro, M.L.S., *Librarian*  
Elizabeth Rosenbloom, M.L.S., *Librarian*  
Heather Walters, M.L.S., *Librarian*  
Yu Zhang, M.L.S., *Librarian*

## FINANCE AND ADMINISTRATION

Robert J. Maciag, M.S., *Senior Vice President, Finance & Administration*  
Steven B. Berenback, M.A., *Dean, Student Records & Accounts/University Registrar*

Ellen Bussard, M.S., *Assistant Vice President, Finance & Administration*  
Peter Brady, B.S., *Manager, Maintenance & Facilities*  
Ellen F. Hartigan, M.A., *Assistant Vice President, Enrollment & Financial Aid Services*

### **Enrollment & Financial Aid Services**

Ellen F. Hartigan, M.A., *Assistant Vice President, Enrollment & Financial Aid Services*

### **Admissions**

Peter G. Jordan, B.A., *Dean, University Admissions*  
Drew Newitt, B.A., *Associate Dean, Admissions/Director, Undergraduate Recruitment*  
Anne Greenspoon, M.A., *Associate Dean, Admissions/Director, Graduate Recruitment*  
Beverly Johnson, B.A., *Associate Dean, Admissions/Director, International Recruitment*  
Thomas Briody, B.S., *Admissions Counselor*  
Christopher Gilroy, B.S., *Admissions Counselor*  
Daniel Gallagher, M.S., *Admissions Counselor*

### **Financial Aid**

Veronica Lukas, M.B.A., *Director, University Financial Aid Services*  
John Steve Kerge, B.S., *Associate Director, University Financial Aid Services*  
Mona Goldberg, *Associate Director, University Financial Aid Services*  
Ronald Charles, M.S., *Financial Aid Counselor*  
Mark Kelly, B.S., *Financial Aid Counselor*

### **Student Records & Accounts/Registrar**

Steven B. Berenback, M.A., *Dean, Student Records & Accounts/University Registrar*  
Michael A. Mainiero, M.Ed., *Associate Registrar*

Edythe Feaster, M.A., *Assistant Registrar*  
Ruth Rosen, *Assistant Registrar*  
Debra Mack, M.S., *Assistant Manager, Student Accounts, Brooklyn Campus*  
Patricia Marinaccio, M.S., *Assistant Manager, Student Accounts, Long Island Campus*

### **INSTITUTIONAL ADVANCEMENT**

Helen T. Lowe, M.B.A., *Senior Vice President, Institutional Advancement*  
Carmel Rosa, M.A., *Director, Development*  
Mary Ann Scalia, M.A., *Director, Public Relations & Publications*  
Vernon Goetcheus, Ph.D., *Director, Alumni Relations*  
Martha Certilman, B.A., *Director, External Affairs & Special Events*  
Margaret Picher, Ph.D., *Senior Development Associate*  
Thomas Daly, M.S., *Associate Director, Development*  
Audrey Andrews, B.A., *Director, Stewardship*  
Eileen Jear, M.A., *Director, Corporate & Foundation Relations*

### **Alumni Association**

Georgia Fisanick '70, *President*  
Martin Dellatto '81, *Vice President*  
Charles Gozdziwski '72, *Vice President*  
Ben Schneidman '71, *Vice President*  
Brett L. Yagel '87, *Secretary*  
Wayne R. Lydon '86, *Treasurer*

# THE FACULTY

Abrami, Philip, <i>ME</i>	205	Cassara, Frank A., <i>CM, EE</i>	99, 134
Abramson, Bernard, <i>MC</i>	176	Cassedy, Edward, <i>EE</i>	134
Ackerberg, Robert C., <i>CE</i>	67	Castleman, Louis S., <i>MS</i>	186
Agi, Faut, <i>EE</i>	136	Cataldo, Joseph C., <i>CI, EV</i>	92, 149
Agosta, Vito D., <i>AE</i>	61	Cavanna, John G., <i>H</i>	159
Alexandropoulos, N.D., <i>PH</i>	215	Chang, John H., <i>EE</i>	136
Alpern, Milton, <i>CI</i>	92	Chao, Jonathan, <i>CM, EE</i>	99, 135
Appel, Arthur, <i>CS, HU</i>	111	Chen, X.K., <i>EE</i>	136
Arky, Michael, <i>HU</i>	159	Chen, Mon Song, <i>IF</i>	166
Armenakas, Anthony E., <i>AE, ME</i>	61, 204	Cheo, Bernard R.S., <i>EE, EP</i>	134, 138
Arnold, Stephen, <i>PH</i>	214	Choe, Wolhee, <i>HU</i>	159
Aronov, Boris, <i>CS</i>	111	Choudhury, Deo C., <i>PH</i>	214
Aronson, Raphael, <i>PH</i>	214	Cohen, Paul, <i>CI, TP</i>	93, 237
Atkatsh, Robert, <i>ME</i>	205	Corry, Robert, <i>ME</i>	205
Aupperle, Kenneth, <i>CS</i>	112	Cortegiano, Michael, <i>MG</i>	174
Ayoub, Nicholas, <i>CI</i>	93	Cowman, Mary K., <i>CH, PS</i>	74, 218
Bachman, George, <i>MA</i>	193	Cresci, Robert J., <i>AE</i>	61
Bagchi, Sidhartha, <i>CI, EV</i>	92, 149	Curreri, John R., <i>ME</i>	205
Balsara, Nitash P., <i>CE, PS</i>	67, 218	D'Amato, Mark, <i>SS</i>	226
Banks, Ephraim, <i>CP, CH</i>	75	D'Amico, Louis, <i>CI</i>	93
Barancik, Jerome, <i>IE</i>	163	D'Antonio, Carmine, <i>MS</i>	185
Bass, Boris, <i>ME</i>	204	Dame, Enid, <i>HU</i>	159
Bass, Hilda, <i>PH</i>	214	Das, Nirod K., <i>EE, EP</i>	135, 138
Bellingham, Richard, <i>MF</i>	181	David, Byron, <i>MG, TM, MC</i>	174, 176, 230
Benenati, Robert, <i>CE</i>	67	Daids, Douglas A., <i>CM, EP, EE</i>	99, 138, 135
Bentson, James, <i>AE</i>	61	DeCiccio, Paul R., <i>CI</i>	92
Berg, Alfred, <i>CI</i>	92	Deutsch, Emeric, <i>MA</i>	193
Bergstein, Leonard, <i>EE, EP</i>	134, 138	DeVries, Duane, <i>HU</i>	159
Bergstein, Shalom S., <i>EE</i>	136	Dodd, Lawrence, <i>CE, PS</i>	67, 218
Berliner, Traci, <i>MG</i>	174	Don, Jodi, <i>HU</i>	159
Bernstein, Steven, <i>MF</i>	181	Doucette, David R., <i>CS</i>	111
Bertoni, Henry L., <i>EE, EP</i>	134, 138	Drance, Daniel, <i>MA</i>	194
Bienstock, Barbara, <i>SS</i>	226	Drenick, Rudolf F., <i>EE</i>	136
Birenbaum, Leo, <i>EE, EP</i>	136	Dropkin, John J., <i>PH</i>	214
Blessner, William, <i>ME</i>	205	Egan, Walter, <i>PH</i>	215
Bloch, Benjamin, <i>PH</i>	214	Ehrlich, Reva, <i>HU</i>	159
Bloom, Martin H., <i>AE, ME</i>	61, 205	Eirich, Frederick, <i>CH</i>	74
Bolle, Donald, <i>EE</i>	134	Eisenberg, Anne, <i>HU</i>	159
Bongiorno, Joseph J., Jr., <i>EE, SE</i>	134, 228	Falcochio, John C., <i>CI, TP</i>	90, 237
Bontempo, Charles J., <i>IF</i>	166	Farber, Herman, <i>EE</i>	136
Boorstyn, Robert R., <i>EE, IF</i>	134, 166	Fares, Nabil, <i>CI</i>	91
Bralla, James G., <i>MF</i>	181	Farrell, Robert J., <i>CE</i>	67
Braziel, Maureen, <i>PE</i>	247	Feknous, Barbara, <i>HU</i>	159
Bruins, Paul F., <i>CE</i>	67	Feknous, Mohammed, <i>CS</i>	112
Bugliarello, George, <i>CI</i>	90	Felsen, Leopold B., <i>EE, EP</i>	134, 138
Burkinshaw, Lawrence, <i>MC</i>	176	Fialkow, Aaron, <i>MA</i>	194
Cadoff, Irving B., <i>MS</i>	186	Field, Reva T., <i>HU</i>	159
Cahill, Patrick T., <i>PH</i>	214	Fisher, George J., <i>MS</i>	186, 249
Cahn, Robert, <i>IF</i>	166	Flynn, Robert J., <i>CS, IF</i>	111, 166
Cardenas, Raul R., Jr., <i>CI, EV</i>	92, 149	Folan, Lorcan, <i>PH</i>	214
Carin, Lawrence, <i>EE, EP</i>	135, 138	Foster, Ronald M., <i>MA</i>	194
Carter, John, <i>CE</i>	74		

Fox, Ingo, <i>CI</i>	92	Kao, John, <i>IE</i>	164
Frankl, Phyllis G., <i>CS</i>	111	Kapfer, William, <i>CE</i>	67
Freyre, Frederick W., <i>EE</i>	136	Kaplan, Seymour, <i>MG, MC</i>	174, 176
Friedman, David, <i>MF</i>	181	Karamouz, Mohammad, <i>CI, EV</i>	92, 149
Frisch, Ivan T., <i>CS, EE</i>	110, 134	Karnaugh, Maurice, <i>CS</i>	111
Fusco, Peter, <i>HU</i>	159	Kash, Peter M., <i>MG</i>	174
Gabriel, Daniel, <i>HU</i>	159	Kaufman, Harold G., <i>MG</i>	174
Gadalla, Kamal A., <i>CI</i>	93	Kaufman, John, <i>CS</i>	112
Garetz, Bruce A., <i>CH</i>	74	Kelly, Charles A. <i>IE, MF, ME</i>	163, 181, 204
Gettleman, Marvin E., <i>SS</i>	225	Kemper, Joseph, <i>AE, ME</i>	61, 205
Ghriga, Mohammed, <i>CS</i>	111	Kershenbaum, Aaron, <i>IF, TM</i>	166, 230
Giordano, Anthony B., <i>EE</i>	136	Khorrani, Farshad, <i>CM, EE, SE</i>	99, 135, 228
Gogolak, Carl, <i>MA</i>	194	Kim, Dong-Soo, <i>CI, EV</i>	91, 149
Gohari, Jalal, <i>EE</i>	136	Kim, Seung P., <i>CM, EE</i>	99, 135
Goldberg, Martin, <i>AE</i>	61	Kinsky, Terance, <i>MF, ME</i>	181, 204
Goodman, Alvin S., <i>CI, EV</i>	90, 148	Kiszenick, Walter, <i>PH</i>	214
Gordon, Barry V., <i>CS</i>	111	Kjeldaas, Terje, Jr., <i>PH</i>	214
Goulias, Dimitrios G., <i>CI, TP</i>	91, 237	Kleinhaus, Suzanne, <i>HU</i>	159
Grand, Bernard A., <i>CI</i>	92	Klosner, Jerome M., <i>AE, ME</i>	61, 204
Graner, William F., <i>CI, EV</i>	93, 149	Koenig, Daniel, <i>MF</i>	181
Green, Mark M., <i>CH, PS</i>	74, 218	Korfhage, Willard, <i>CM, CS</i>	99, 111
Greenbaum, Edward, <i>MG</i>	174	Koutsospyros, Agemmemnon, <i>CI, EV</i>	93, 149
Greenstein, Michael, <i>MF</i>	181	Kraft, Walter, <i>CI</i>	92
Grieco, Linda Anne, <i>CS</i>	111	Kramer, Pamela E., <i>SS</i>	225
Grieve, Phillip, <i>EE</i>	136	Krautheimer, David, <i>MG</i>	174
Griffel, Giora, <i>EE, EP</i>	135, 138	Kreiling, Frederick C., <i>SS</i>	226
Griswold, Albert H., <i>CI</i>	92	Kuiken, Kathryn, <i>MA</i>	194
Gross, Kenneth, <i>TM</i>	230	Kumar, Sunil, <i>MF, ME</i>	181, 204
Grosser, Paul W., <i>CI, EV</i>	93, 149	Kunhardt, Erich E., <i>EP, PH</i>	138, 214
Gruber, Helmut, <i>SS</i>	225	Kuo, Szu-Ping, <i>EE, EP</i>	134, 138
Guggenheimer, Heinrich, <i>MA</i>	194	Kurman, Mark, <i>MG</i>	174
Habib, Philip A., <i>CI, TP</i>	92, 237	Kurz, Ludwik, <i>EE</i>	134
Haddad, Richard A., <i>EE, SE</i>	134, 228	Kwei, T.K., <i>CH, CE, PS</i>	67, 74, 218
Hadimioglu, Haldun, <i>CM, CS</i>	99, 111	Laemmel, Arthur E., <i>CS, EE</i>	112
Hajallie, Kamal, <i>MA</i>	194	Lancevich, Edward, <i>CS</i>	111
Hall, Robert, <i>IE</i>	163	Landau, Gad M., <i>CS</i>	110
Hanggi, Peter, <i>PH</i>	215	LaTourrette, James T., <i>CS</i>	112
Harris, Donald, <i>MG</i>	174	Leahy, Robert, <i>EE</i>	136
Hausman, Howard, <i>EE</i>	136	Lederman, Samuel, <i>AE</i>	61
Helly, Walter, <i>IE, SE, TP</i>	164, 228, 287	Lee, Tony T., <i>EE</i>	134
Herhach, Leon, <i>MA</i>	194	Leeb, I. Leonard, <i>SS</i>	226
Hessel, Alexander, <i>EE</i>	136	Lehman, Sheila, <i>SS</i>	226
Hirshon, Ronald, <i>MA</i>	193	Lerner, Linda, <i>HU</i>	159
Hockney, Donald, <i>CS</i>	110	Leung, K. Ming, <i>PH</i>	214
Hochstadt, Harry, <i>MA</i>	194	Levi, Enrico, <i>EE</i>	136
Hoover, Charles W., Jr., <i>IE, MF, ME</i>	163, 181, 204	Levine, Ernest, <i>MS</i>	186
Horodniceanu, Michael, <i>CI, TP</i>	92, 237	Levine, Nathan, <i>IE, MF</i>	163, 181
Huber, Tito, <i>PH</i>	214	Levinson, Herbert S., <i>CI, TP</i>	90, 237
Hummel, Susan Flynn, <i>CM, CS</i>	99, 111	Levon, Kalle, <i>CH, PS</i>	74, 218
Hunt, Donald F., <i>EE</i>	134	Levy, Robert L., <i>AE</i>	61
Imber, Murray, <i>ME</i>	204	Leyh, Carl Henry, <i>PH</i>	214
Isom, Morris P., <i>AE</i>	61	Lieberman, Burton, <i>MA</i>	193
Ivanchenko, Yuli M., <i>PH</i>	215	Lin, Feng-Bao, <i>CI</i>	91
Jacoby, Stanley J., <i>MG</i>	174	Lockley, Edward E., <i>CI</i>	93
Jones, Barry, <i>CS, IF</i>	111, 166	Loebl, Ernest M., <i>CH</i>	75
Joseph, Joel, <i>MG</i>	174	Lomp, Gary, <i>EE</i>	136
Juran, Ilan, <i>CI, EV, TP</i>	90, 148, 236	Lou, J. Jong, <i>CI</i>	92
Juretschke, Hellmut J., <i>PH</i>	214	Lowenthal, Jack A., <i>PH</i>	214
Kalkhoran, Iraj M., <i>AE</i>	61	Lu, I-Tau, <i>EE, EP</i>	135, 138
Kang, Sung K., <i>MS</i>	186	Lupton, Daniel E., <i>MG</i>	174

## THE FACULTY

Lutwak, Erwin, <i>MA</i>	193	Pascali, Raresh, <i>ME</i>	204
Lynch, Barbara, <i>HU</i>	159	Patel, Sharad A., <i>AE, ME</i>	61, 205
MacDonald, Kathleen, <i>MG</i>	174	Pearce, Eli M., <i>CE, CH, PS</i>	67, 74, 218
Mandelbaum, Richard, <i>CS, EE, MA</i>	110, 135, 193	Peterson, Norman C., <i>CH</i>	74
Marcuvitz, Nathan, <i>EE</i>	136	Petrucci, Sergio, <i>CH</i>	74
Margolin, Harold, <i>MS</i>	186	Philips, Donald, <i>SS</i>	226
Marino, Sylvester, <i>MG</i>	174	Pickel, Paul F., <i>MA</i>	194
Marks, Sylvia Kasey, <i>HU</i>	159	Pillai, S. Unnikrishna, <i>EE</i>	135
Marshall, Clifford W., <i>MA</i>	194	Pomerantz, Melvin, <i>PH</i>	214
Martini, Joseph, <i>PE</i>	247	Post, Benjamin, <i>PH</i>	214
McCullough, Malcolm, <i>SS</i>	226	Prassas, Elena Shenk, <i>CI, TP</i>	91, 237
McNelis, Patrick, <i>MG</i>	174	Preiser, Stanley, <i>CS, MA</i>	112, 134
McShane, William R., <i>CI, IE, ME, SE, TP</i>	91, 163, 204, 228, 237	Protopapas, Angelos L., <i>CI, EV</i>	91, 149
Meepagala, Sarath C., <i>PH</i>	214	Rahimian, Ahmad, <i>CI</i>	93
Menashe, Louis, <i>SS</i>	225	Raichle, William, <i>MG</i>	174
Menes, Meir, <i>PH</i>	214	Rajaram, Subramani, <i>MF</i>	181
Mermelstein, David, <i>SS</i>	225	Rasmussen, E. Hart, <i>IE, TM, MG, MC</i>	166, 174, 176, 230
Merzin, Oleg, <i>PH</i>	215	Ratay, Robert, <i>CI</i>	91
Meyer, Susan, <i>MG</i>	174	Rechtschaffen, Bernard, <i>HU</i>	159
Meyninger, Rita, <i>CI, EV</i>	92, 149	Reiser, Arnost, <i>CH, PS</i>	74, 218
Mijovic, Jovan, <i>CE, PS</i>	67, 218	Riley, Cynthia, <i>HU</i>	159
Mikochik, Stephen T., <i>CI</i>	92	Riseborough, Peter, <i>PH</i>	214
Miller, Edward Y., <i>MA</i>	194	Rizzi, Anthony J., <i>CI</i>	92
Miller, James E., <i>CI</i>	92	Roess, Roger P., <i>CI, TP</i>	91, 237
Mishkin, Eli Absalom, <i>EE</i>	136	Rogers, Joel, <i>MA</i>	194
Mitchell, Muni, <i>EE</i>	136	Romano, Frank J., <i>ME</i>	205
Moallemi, M. Karim, <i>MF, ME</i>	181, 204	Rossetti, Gabriel D., <i>CI</i>	93
Molof, Alan H., <i>CI, EV</i>	91, 148	Roth, Bernard, <i>ME</i>	205
Monroe, Charles, <i>MG</i>	174	Rothman, Herbert, <i>CI</i>	92
Morawetz, Herbert, <i>CH</i>	75	Rubinson, Teresa, <i>TM</i>	230
Morduchow, Morris, <i>AE</i>	61	Ruston, Henry, <i>CS, EE</i>	110, 135
Moretti, Gino, <i>AE</i>	61	Ruston, Lillian S., <i>CS</i>	111
Mossiman, Ary, <i>MG</i>	174	Sakala, Michael J., <i>CI, EV</i>	93, 149
Motzkin, Shirley M., <i>CH</i>	74	Sampson, David, <i>CI, TP</i>	93, 237
Moulic, James, <i>EE</i>	136	Sandford, Colleen M., <i>HU</i>	159
Mueller, Wheeler, K., Jr., <i>ME</i>	205	Sansone, Gennaro E., <i>CI, TP</i>	93, 237
Mulcahy, F. David, <i>SS</i>	226	Sarachik, Philip E., <i>EE, SE</i>	135, 228
Myerson, Allan S., <i>CE</i>	67	Sastri, Sankar, <i>MS</i>	186
Nadler, Alan M., <i>HU</i>	159	Scarl, Donald B., <i>PH</i>	214
Nanda, Ravinder, <i>IE</i>	164	Schachter, Harry, <i>EE</i>	136
Nardo, Sebastian V., <i>AE</i>	61	Schaeffer, Raymond, <i>CI, TP</i>	93, 237
Needham, Nancey J., <i>IE, MG, TM</i>	166, 173, 230	Scheiner, Lowell L., <i>HU</i>	159
Newhouse, Richard, <i>CI, TP</i>	93, 237	Schiffer, Robert, <i>MG</i>	174
Newstein, Maurice C., <i>EE</i>	136	Schillinger, A. George, <i>MG, MC, TM</i>	173, 176, 230
Nourbakhsh, Said, <i>MS</i>	185	Schleuning, H. William, <i>PH</i>	214
Nukhopadhyay, Sharmila, <i>MS</i>	186	Schlosser, Joseph R., <i>MC, TM</i>	176, 230
Okamoto, Yoshiyuki, <i>CH, PS</i>	74, 218	Schmidt, Jeanette P., <i>CS</i>	111
Oliner, Arthur A., <i>EE</i>	136	Schnatter, Wayne F.K., <i>CH</i>	75
Oltrogge, Cal, <i>MF</i>	181	Schurig, W. Fred, <i>CE</i>	67
Ong, Say, <i>CI, EV</i>	91, 149	Settle, Thomas B., <i>SS</i>	225
Osborne, Clifford, <i>HU</i>	159	Sforza, Pasquale M., <i>AE</i>	61
Othmer, Donald F., <i>CE</i>	67	Shaffer, Bernard W., <i>ME</i>	205
Otugen, M. Volkan, <i>AE</i>	61	Shahvar, Zohreh, <i>CI, EV</i>	93, 149
Oyibo, Gabriel, <i>AE</i>	61	Shamis, Sidney S., <i>EE</i>	136
Pagdadis, Sotiris A., <i>CI, EV</i>	91, 149	Shapira, Reuven, <i>MF</i>	181
Palucz, Istvan, <i>E</i>	136	Shaw, Leonard G., <i>EE, SE</i>	134, 228
Pan, Huo-Hsi, <i>ME</i>	205	Shmoys, Jerry, <i>EE</i>	136
Panwar, Shivendra S., <i>EE, IF</i>	135, 166	Shooman, Martin L., <i>CS, EE, SE</i>	110, 134, 228
Papoulis, Athanasios, <i>EE</i>	136	Sibner, Lesley, <i>MA</i>	194
		Siegel, Dale, <i>MA</i>	194

Sinha, Sri K., <i>CI</i>	92	Wainfan, Nathan, <i>PH</i>	214
Sisson, Patricia, <i>HU</i>	159	Walden, Kenneth, <i>MG</i>	174
Sjursen, Harold, <i>HU</i>	159	Walthers, Eric, <i>CS</i>	111
Smith, Edward J., <i>CS, EE</i>	112, 136	Wang, Ping Chun, <i>CI</i>	92
Snow, Andrew, <i>TM</i>	230	Wang, Wen-Chung, <i>EE, EP</i>	135, 138
Snyder, Joel B., <i>CM, EE</i>	99, 135	Wang, Yao, <i>CM, EE</i>	99, 135
Soehngen, Henry F., <i>CI</i>	92	Weber, Murray, <i>CI</i>	92
Sokol, Mark B., <i>MG</i>	174	Weber, Ernst, <i>EE</i>	136
Spolter, Faige S., <i>PH</i>	214	Weill, Georges, <i>MA</i>	194
Steele, Lowell, W. <i>MC</i>	176	Wein, Joel, <i>CS</i>	111
Stiel, Leonard I., <i>CE</i>	67	Weinig, Sheldon, <i>MS</i>	186
Sutphen, Duncan D., <i>MC, MF</i>	176, 181	Weinless, Martin, <i>MA</i>	194
Sviedrys, Romualdas, <i>SS</i>	226	Weinbaum, Irwin, <i>CI</i>	92
Szeglin, Arthur R., <i>MG</i>	174	Weindling, Joachim I., <i>IE, SE</i>	164, 228
Tamir, Theodor, <i>EE, EP</i>	135, 138	Weindling, Ralph, <i>MG, MC</i>	173, 176
Tanacredi, John T., <i>CI, EV</i>	92, 149	Weiss, Gerald, <i>EE</i>	136
Tassioulas, Leandros, <i>EE</i>	135	Wener, Richard, <i>SS</i>	226
Teraoka, Iwao, <i>CH, PS</i>	75, 218	Werner, Jack E., <i>AE</i>	61
Terzouli, Andrew, J., <i>MA</i>	194	Wang, Sung H., <i>MS</i>	185
Tesoro, Guillian, <i>CH, PS</i>	75, 218	Wiener, Anthony J., <i>MG, MC</i>	174, 176
Thevanayagan, Theva S., <i>CI, EV</i>	91, 149	Willing, Stanley S., <i>MG</i>	174
Thomas, John C., <i>MF</i>	181	Wolf, Edward L., <i>PH</i>	214
Thompson, Carol, <i>PH</i>	214	Wong, Edward K., <i>CM, CS</i>	99, 111
Thorsen, Richard, <i>ME</i>	204	Wright, Chilton A., <i>CI</i>	92
Tjaden, Gary, <i>CS</i>	111	Xu, Zhiwei, <i>CM, CS</i>	99, 111
Tooney, Nancy M., <i>CH, EV</i>	75, 148	Yallaoui, El-Bachir, <i>MA</i>	194
Touma, Andre, <i>CI</i>	92	Yang, Deane, <i>MA</i>	193
Tsotras, Vassilis J., <i>CS, EE</i>	111, 135	Yapjajakis, Constantine, <i>CI, EV</i>	92, 149
Tulsi, Balram, <i>HU</i>	159	Yates, Janet K., <i>CI, EV</i>	91, 148
Tzes, Anthony P., <i>IE, MF, ME</i>	163, 181, 204	Yoon, C-Y John, <i>CI</i>	91
Ulerio, Jose M., <i>CI, TP</i>	91, 237	Youla, Dante C., <i>EE, SE</i>	135, 228
Vafakos, William P., <i>ME</i>	204	Zabar, Zivan, <i>EE</i>	135
Van Slyke, Richard, <i>CS, EE, IE, TM</i>	110, 135, 166, 230	Zervos, Spilios, <i>ME</i>	205
Vasilaky, Walter, <i>CS</i>	111	Ziegler, Edward N., <i>CE, EV</i>	67, 148
Veit, Robert C., <i>CI</i>	92	Zinzer, Louis, <i>PE</i>	247
Vogl, Otto, <i>CH, PS</i>	75, 218	Zuk, John S., <i>MF</i>	181
Vohs, Walter, <i>MA</i>	194	Zurawsky, Walter P., <i>CE, PS</i>	67, 218
Voltz, Peter, <i>EE, SE</i>	135, 228	Zauderer, Erich, <i>MA</i>	194
Vradis, George C., <i>MF, ME</i>	181, 204		

**AE** Aerospace Engineering

**CE** Chemical Engineering

**CH** Chemistry

**CI** Civil Engineering

**CM** Computer Engineering

**CS** Computer Science

**EE** Electrical Engineering

**EP** Electrophysi

**EV** Environmental Engineering and Environmental Health Science

**HU** Humanities and Communications

**IE** Industrial Engineering

**IF** Information Systems Engineering

**MA** Mathematics and Statistics

**MC** Management of Technology

**ME** Mechanical Engineering

**MF** Manufacturing Engineering

**MG** Management

**MS** Materials Science and Engineering (Metallurgy)

**PE** Physical Education and Athletics

**PH** Physics

**PS** Polymer Science and Engineering

**SE** Systems Engineering

**SS** Social Sciences

**TM** Telecommunications and Computing Management

**TP** Transportation

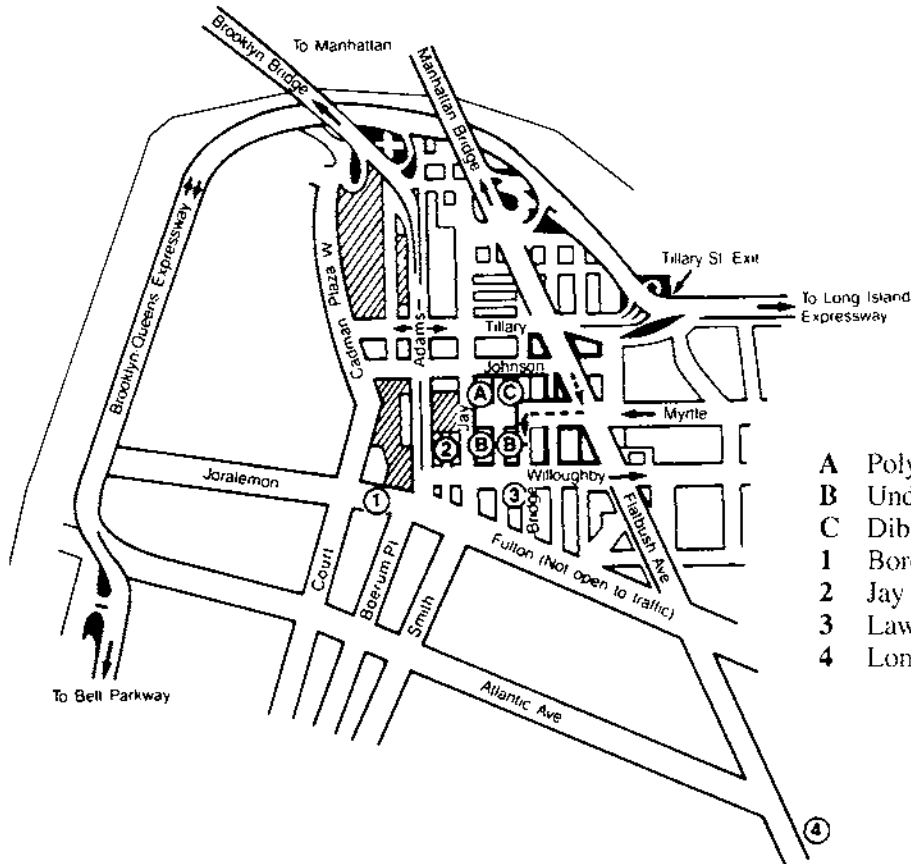
# INDEX

A Brief Guide to Course Descriptions	55	Degrees Offered at Polytechnic	47
Academic Calendar	7	Degrees with Honors	51
Academic Departments	10	Department of Student Life	22
Academic Honor Students	239	Dibner Library/CATT	12
Academic Policies	16	Disclaimer	263
Academic Probation	19	Disqualification	20
Academic Programs	9	Doctor of Philosophy Degrees	52
Academic Programs & Policies	15	Dual Degree Program with NYU	233
Academic Programs, Degree Requirements and Curricula	45	Dual Majors	51
Academic Standing & Probation	19	Dual Undergraduate Degrees	51
Academic Warning	19	Early Admission Plan	29
Accident & Sickness Insurance	24	Early Graduate Admission	29
Add/Drop Program Adjustments	40	Early Registration	40
Administration, The	252	East Residence Hall	13
Administrative Offices	6	Economics	219, 224
Admissions	28	Electrical Engineering	113
Advisement for Registration	40	Electrical Engineering BS/MS Accelerated Honors Program	117
Aerospace Engineering	56	Electrical Engineering Computer-Aided Design	116
Aid for Part-Time Study (APTS)	34	Electrophysics	137
Alcohol & Drugs	24	Employment	33
Alumni	11	Energy Systems Lab (ESL)	10
Analytical Chemistry	72	Engineering	15
Application for Degree	53	Enrollment by Racial/Ethnic Status	44
Application Process	29	Enrollment 1992-1993	44
Applied Mathematics	192	Environmental Engineering	85, 139
Athletics	25, 247	Environmental Health Science	139
Auditing Courses	18	Examinations	28
Bachelor of Science Degrees	48	Faculty	11, 254
Basic Degree Requirements	48	Family Educational Rights & Privacy Act - The Buckley Amendment	21
Biochemistry	73	Federal & State Sponsored Programs	34
Board of Trustee Scholarships	35	Federal Campus-Based Programs	33
Brooklyn Center at Metro/Tech	12	Federal College Work-Study Program	34
Brooklyn Union Gas Company	12	Federal PELL Grants	34
Buckley Amendment	21	Federal Perkins Loans	34
Business-Magazine Journalism	151	Federal Stafford Loan Program (formerly GSL)	37
Campus Centers	12	Federal Stafford Student Loan Program	33
Campus Housing at the Long Island Center	26	Federal Supplemental Edu. Opportunity Grant (SEOG)	34
Campus Housing Requirements	27	Federal Supplemental Loans for Students	33, 38
Campus Housing Service at the Brooklyn Center	26	Federal Unsubsidized Stafford Loan	33, 38
Campus Life & Supporting Services	22	Financial Aid	32
Career Services Office	22	Financial Reporting	151
Center for Advanced Tele. Tech. (CATT)	10	Fraternalities	26
Center for Applied Large-Scale Computing (CALC)	10	French	156
Certificate Programs	52	Freshman Admission with Advanced Standing	30
Chase Manhattan Bank	12	Freshman Seminar	50
Chemical Engineering	62	Geiger/Trialkov Scholarships	35
Chemistry	68	General & Institutional Information	5
Civil Engineering	76	Geometry and Topology	192
Class Standing for Undergraduates	17	Geotechnical and Geoenvironmental Engineering	86, 147
Co-Curricular Student Activities	25	Grading Policies	18
College Preview	31	Graduate Admissions	28
Computer Engineering	94	Graduate Advisers	23
Computer Engineering BS/MS Accelerated Honors Program	98	Graduate Certificate Programs	52
Computer Engineering Computer-Aided Design	97	Graduate Fellowships & Assistantships	32
Computer Science	100	Graduate Financial Aid	32
Computer Science Honors Program	101	Graduate Research (Projects, Theses, Dissertations)	53
Construction Management	86, 146	Graduate Students	16
Cooperative Education Program (CO-OP)	37, 240	Graduate Tuition Assistance Program (TAP)	32
Core Curriculum for Engineering Majors	49	Graduate Checklist	50
Corporate & Individually Sponsored Scholarships	36	Grant Aid to Non-New York State Residents	37
Corporation, The	251	Grumman Hall	13
Counseling Services	23	Guidelines on Student Religious Observances	25
Course Description (Brief Guide)	55	Gymnasium	13
Course Substitutions & Other Modifications to Curricula	50	Handicapped Students	24
Credit by Examination (UG Students)	17	Higher Education Opportunity Program (HEOP)	35, 242
Credits for Courses taken elsewhere (Transfer Credits)	16	Highway Engineering	87
Dean of Engineering Scholarships	35	History	219
Dean's List	20	History and History of Science and Technology	221
Definition of Credits & Units	16	History of Polytechnic	9

History, and History and Philosophy of Science and Technology	219	Polytechnic University Scholarships & Grants	35
Honor Societies	25	Polytechnic University-Sponsored Loan	38
Housing	41	Preston R. Bassett Building	13
Humanities and Communications	150	Principal's Scholarship	35
Immunization	24	Probability, Statistics, Operations Research	192
Impact of Refund on Financial Aid	42	Probation	19
Important Financial Aid Policies	38	Professional & Departmental Societies	25
Incomplete Grades	18	Program Adjustments (Add/Drop)	40
Industrial Advertising and Public Relations	151	Program Areas	15
Industrial Engineering	160	Promise Scholarships	35
Information Systems Engineering	165	Psychology and Behavioral Sciences (Anthropology and Sociology)	219, 223
Inorganic Chemistry	72	Publication of Doctoral Dissertations	54
Institute for Imaging Sciences (IIS)	10	Publications	26
Insurance	24	Readmission	31
International Applicants	28	Reduced Tuition Program for H.S. & Two Year CC Teachers	32
International Students	24	Refund of Tuition/Reduction of Liability	42
Interviews & Campus Tours	30	Refund Schedule	42
Introduction	9	Refunds	40
Jacobs Building	12	Registering for Classes	40
Japanese	156	Registration	40
Journalism and Technical Writing, Communications	153	Registration for Theses and Dissertations	53
Late Registration	40	Religious Observances Guidelines	25
Learning Center	22	Repeating Courses	18
Leaves of Absence & Readmission	20	Required Immunization	24
Leo J. Pantas Hall	27	Research Programs & Centers	10
Liberal Arts	16	Research Submission	53
Library	12	Residential Life & Campus Housing	26
Life Sciences Courses	73	Retention	25
Literature	154	Richard L. Conolly Hall	26
Loan Programs	33, 37	Rogers Hall	12
Long Island Center	6, 12	ROTC	244
Main Administration Building	13	ROTC Scholarships	36
Management	15, 167	Routes to Polytechnic	260
Management of Technology	175	Scholarships and Grants	33
Manufacturing Engineering	177	School of Chemical & Materials Science	10
Manuscript Presentation	53	School of Electrical Engineering & CS	10
Master of Science Degrees	52	Sciences & Mathematics	15
Materials Science (Metallurgy)	146	Securities Industry Automation Corp. (SIAC)	12
Mathematical Programming	182	Selection of a Major (UG Students)	16
Mathematics and Statistics	187	Senior Class	43
Maximum Credits Permitted & Registration Status	17	Senior Honor Students	51
Mayor's Graduate Scholarship Program	32	Social Sciences	219
Mechanical Analysis and Design	202	Social, Cultural, Religious Media & Other Organizations	26
Mechanical Engineering	195	Spanish	156
Medical and Science Reporting	151	Special & Visiting Students	31
Metallurgy	146	Statistics On Enrollment and The Student Body	44
MetroTech	12	Student Government	15
Military Science (ROTC)	244	Student Identification	40
Minority Scholars Program	36	Student Profile	44
Modern Languages	156	Student Retention	25
Music and Fine Arts	155	Supplemental Higher Education Loan Financing Program (SHELF)	38
National Action Council for Minorities in Engr. (NACME)	36	Supplemental Loans for Parents	38
New Student Orientation	23	Systems Engineering	227
Nichols Hall	12	Systems, Controls, and Robotics	202
Off-Campus Housing Opportunities	27	Technical Writing	151
Office of Special Services	22	Telecommunications & Computing Management	229
Operations Management	206	Thermal and Fluid Sciences	201
Organic Chemistry	73	Theses and Dissertations	53
Organizations & Associations	25	Transcripts	21
Outstanding Achievement Scholarship	35	Transfer Credits While in Residence	17
Outstanding Transfer Scholarship	35	Transportation	231
Payment of Tuition & Fees	41	Transportation Training & Research Ctr (TTRC)	10
Payment Plans and Options	42	Travel Directions	260
Persistence & Completion Information	44	Tuition & Fees	41
Philosophy and Comparative Religion	155	Tuition Assistance Program (TAP)	34
Physical Chemistry	72	Undergraduate Advisers	23
Physical Education	247	Undergraduate Theses	53
Physics	207	University Code of Conduct	27
Placement Examinations	48	University Degree Requirements	48
Placement Statistics 1992	43	Validation Credits (UG & Grad Students)	17
Policies on Grading & Grades	18	Veterans Administration (VA) Educational Benefits	36
Polymer Chemistry	72	Vietnam Veterans Tuition Awards Supplement (VVTA)	34
Polymer Research Institute (PRI)	10	Weber Research Institute (WRI)	11
Polymer Science and Engineering	216	West Residence Hall	13
Polytechnic Computing Facilities	14	Westchester Center at Hawthorne	6, 13
Polytechnic Grants	36	William H. Nichols Hall	12
Polytechnic Libraries	13	Withdrawal from a Course	18
Polytechnic Loans	33	Withdrawal from the University	20
Polytechnic National Society of Professional Engrs. Scholarship (NSPE)	36	Work-Study Programs	34
Polytechnic University Profile	9	Yes Center	248

# THE ROUTES TO POLYTECHNIC

## BROOKLYN CAMPUS



- A Polytechnic University
- B Underground Public Parking
- C Dibner Library/CATT Building
- 1 Borough Hall 2, 3, 4, 5, Subways
- 2 Jay St. Borough Hall A, F, C, Subways
- 3 Lawrence St. R, M, Subways
- 4 Long Island Railroad – Flatbush Ave.

### From Manhattan

By Subway—A, C or F train to Jay St.-Borough Hall; or the 2, 3, 4 or 5 subway to Borough Hall (walk to Fulton and make a left onto Jay) or the R or M to Lawrence St.

By Car—Take the FDR Drive to the Brooklyn Bridge, make the first left after the bridge onto Tillary and a right onto Flatbush.

\*From Flatbush go right onto Myrtle and the second left onto Bridge St. Public parking is available on the lower levels of the SIAC and Brooklyn Union Gas buildings for \$10 a day.

### From Queens or the Bronx

By Car—Take the Brooklyn-Queens Expwy. to Tillary St. and then left onto Flatbush Ave. Continue from \*.

### From Staten Island

By Car—Take the Verrazano Narrows Bridge to the Brooklyn-Queens Expwy. to the Tillary St. exit. Make a left onto Flatbush Ave. Continue from \*.

### From New Jersey

By Car—From the George Washington Bridge take the Harlem River Drive to the FDR Drive or Holland Tunnel to Brooklyn Bridge. (Continue as from Manhattan).

### From Brooklyn or Long Island

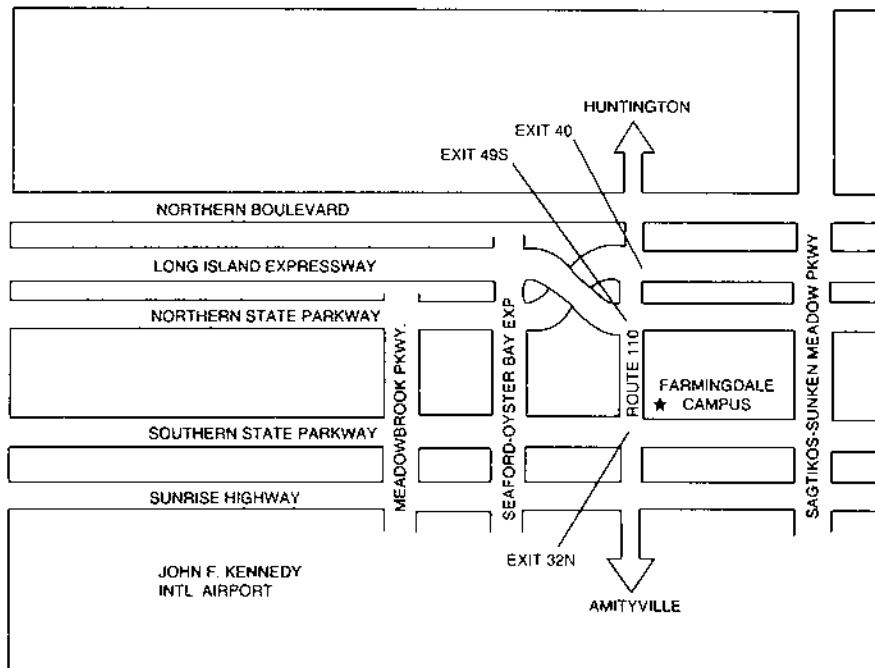
By Train—Take the Long Island Railroad to Flatbush Ave. Then take a taxi, bus #B67 to Metrotech on Jay St., or the R or M subway to Lawrence St. It's about a one-mile walk from the LIRR station; go to the Fulton Mall and make a left, then a right onto Jay St.

By Car—Brooklyn-Queens Expwy. to the Tillary St. exit. Go left onto Flatbush, continue from \*.

### From Westchester

By Car—Take the Major Deegan or Cross Bronx Expwy. to FDR Drive to Brooklyn Bridge or the Triborough, Whitestone or Throgs Neck Bridge to Brooklyn-Queens Expwy. to Tillary St. From there take a left onto Flatbush Ave., continue from \*.

**LONG ISLAND CAMPUS AT FARMINGDALE**



**From New York City**

By Train—Take the Long Island Railroad (LIRR) to the Amityville station—taxi or buses available.

By Car—Take the Long Island Expressway to Exit 49S. South on Route 110 four miles to campus on left. Or, Northern State Parkway to Exit 40S. then south on Route 110 for five miles to campus on left. Southern State Parkway to Exit 32N, then north on Route 110 for one mile, campus on right.

**From New Jersey**

By Train—Penn Central, or Commuter Lines to Penn Station, the LIRR as above.

By Car—Same directions as from New York City.

**From Westchester**

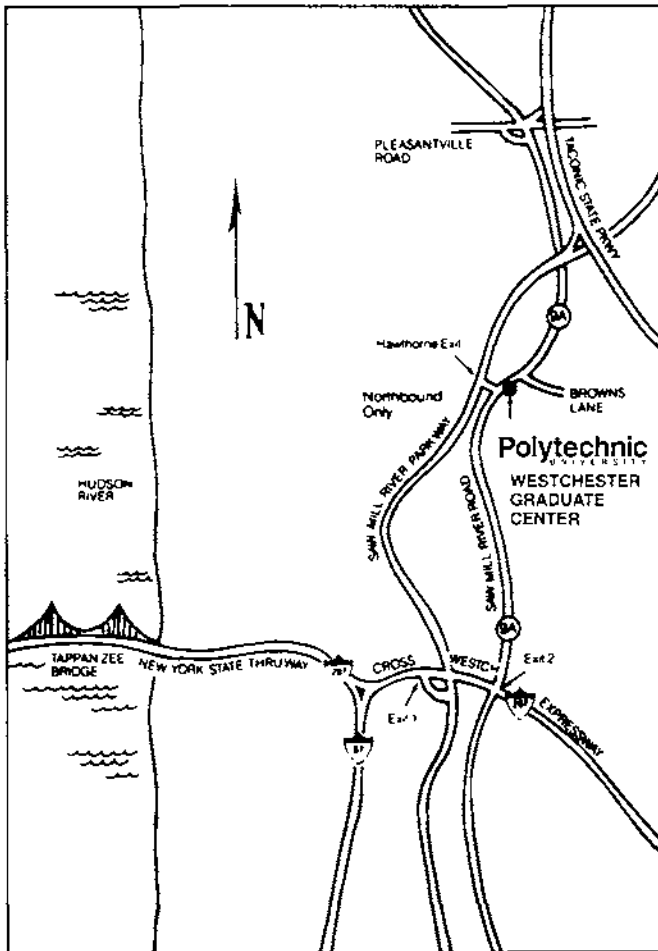
By Train—To Grand Central, taxi or Shuttle (S) train to Penn Station, LIRR as above.

By Car—Whitestone or Throgs Neck Bridge to Cross Island Pkwy. (South) to Long Island Expressway East or Northern State Parkway East (then same as from NYC).

**From Eastern Long Island**

By Car—Long Island Expressway to Exit 49S which is Route 110; the campus is four miles on the left. Or, Southern State Parkway to 32 North, (Route 110) for one mile, campus on right.

**WESTCHESTER GRADUATE CENTER**



**From Points West**

NY State Thruway East across Tappan Zee Bridge. Take Exit 8. Going east on Interstate 287, take Exit 1: Saw Mill River Pkwy. North. Go 3 miles and take the Hawthorne (Route 9A) Exit to Saw Mill River Road. Turn left (north on 9A, Polytechnic is on the right).

**From Points East**

Going west on Interstate 287 take Exit 2: Route 9A-Saw Mill River Rd. Go north 3 miles, Polytechnic is on the right.

**From Points South**

Going north on Saw Mill River Pkwy, take the Hawthorne exit to Saw Mill River Rd. Follow directions above for traveling from the west.

**From Points North**

Take the Taconic State Pkwy. South to Pleasantville Rd. Go 1/4 mile west to Route 9A South. Go 4 miles. Polytechnic is on the left.



Polytechnic University is an equal opportunity institution. The University is diverse in its representation of various racial, ethnic, and economic backgrounds. It strives to maintain that diversity not only to comply with state and federal statutes, but also to provide an educationally desirable environment.

The University does not discriminate in admission, or access to, or treatment or employment in its programs and activities on the basis of race, color, religion, national origin, handicap, Vietnam veteran status, age, or sex. This statement is published in part to fulfill the requirements of Section 86.9 or title 45, Code of Federal Regulations, which implements Title IX of the Education Amendments of 1972.

Inquiries about the above policies may be directed to the Affirmative Action Office, Polytechnic University, Six Metrotech Center, Brooklyn, New York 11201.

The University is authorized under federal law to enroll non-immigrant alien students.

This catalog is not intended to be, and should not be regarded as, a contract between Polytechnic University and any student or other person.

# NOTES